Habitat Selection by American Martens (*Martes americana*) in Coastal Northwestern California

by

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A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Presented April 25, 2003
Commencement June 2003

AN ABSTRACT OF THE THESIS OF

Keith M. Slauson for the degree of Master of Science in Forest Science
presented on April 25, 2003.
Title: Habitat Selection by American Martens (*Martes americana*) in Coastal Northwestern California.

Abstract approved:

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John P. Hayes

The Humboldt marten, *Martes americana humboldtensis*, has undergone a dramatic decline throughout its historical distribution in coastal Northwestern California. There is currently only one known population occupying an area occurring in <5% of the historical distribution of the subspecies. Conservation and management efforts to benefit this population are hampered by lack of information on the habitat ecology of martens in the coastal forest of northwestern California. Furthermore there have been no investigations of the habitat ecology of marten populations anywhere in the coastal forests of the Pacific States.

I investigated habitat relationships of the only known population of martens within the historical distribution of *M. a. humboldtensis* at three spatial scales (microhabitat, stand, and home range) and in relation to four forest management regimes (industrial timberlands, and U. S. Forest Service (USFS) matrix lands, late-successional reserves, and wilderness). Over 12 months of fieldwork during 2000 and 2001, I detected martens at 26 of 159 track plate sample units distributed on a systematic grid located over the region known to be occupied by the population. I used an information-theoretic approach to rank 56 *a priori* candidate models that described hypothesized habitat relationships at each spatial scale.

Marten detections occurred in two distinct habitat types, those with forests on serpentine soils and forests associated with more productive soil types, which are more common in the region. At the microhabitat scale in serpentine habitats, martens were detected at sites with dense shrub cover, sparse tree cover, and abundant surface rocks. Dense shrub cover and abundant surface rocks may provide key overhead and escape cover for martens in serpentine habitats. At the microhabitat scale in non-serpentine habitats martens were detected at sites having the most mesic aspects, with dense tree and shrub cover, and with a higher abundance of large diameter snags. At the stand scale martens selected conifer-dominated stands with dense shrub cover in the latest seral stages (old growth and late-mature) in non-serpentine habitats and variable seral stages in serpentine habitats. At the home-range scale the probability of detecting a marten decreased with increasing amounts of logging within 1-km of the sample unit and increased with increasing maximum patch size of old growth, old growth plus late-mature, or serpentine habitat within 1-km of the sample unit. Martens were detected significantly more frequently in USFS lands than in private industrial timberlands. Within USFS lands, martens were detected most frequently in matrix and late-successional reserves, and least frequently in the wilderness area.

This study provides new information on the habitat ecology of martens in the coastal forests of northwestern California. It demonstrates the importance of investigating marten habitat at multiple spatial scales and provides insights to linkages among scales and how martens respond to forest management. It also provides information to aid conservation and restoration of martens in northwestern California through identification of areas currently occupied or with suitable habitat, information to identify suitable habitat in areas outside the study area, and information to guide conservation planning for martens and site-specific habitat restoration.

Master of Science thesis of Keith M. Slauson presented on April 25, 2003.

APPROVED:

Major Professor, representing Forest Science

Head of the Department of Forest Science

Dean of the Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Keith M. Slauson, Author

ACKNOWLEDGEMENTS

Many individuals are deserving of recognition for their contributions to this project. I must first thank Bill Zielinski for giving me the opportunity to challenge myself with this project and for the guidance and friendship he provided throughout. Next I must thank my major professor, John Hayes, for his support and guidance throughout the design of the project and development of this thesis. I would also like to thank my committee members John Tappeiner and Richard Schmitz for their insight and suggestions during the development of the project and their thoughtful comments on this thesis.

I want to especially thank and acknowledge the contributions and personal sacrifices made by those who assisted me both as crew members and as friends in the coastal mountains: Lisa Cross, Jessica Flayer, Jessie Grossman, Heather Lessig, Julian Mangas, Giovanni Manghi, Ben Marckmann, Brit O'Brien, Jody Pennycook, David Prins, Nick Polato, Jonothan Storm, Noel Soucy.

Many people made important contributions along the way. I must thank Quentin Youngblood, Brenda Devlin, Kristin Schmidt, and especially Tony Hacking of the Six Rivers National Forest for logistical and field support. Rick Schlexer, Chet Ogan, and Rick Truex of the Redwood Sciences Lab provided important field and logistical support. Jan Werren also of the Redwood Sciences Lab provided important GIS support and training. Thomas Jimerson and Jeff Jones of the Ecology Program of the Six Rivers National Forest provided important contributions and support in the use of the vegetation information for the study region. Lisa Gaino and Manuela Huso of the Department of Forest Science provided important statistical advice and support.

I wish to thank the Simpson Timber Company and Keith Hamm, Lowell Diller, and Chris Howard for assisting us with access and logistics on company lands.

And finally I must acknowledge the individuals and organizations who helped to provide the financial support: Esther Burkett, California Department of Fish and Game; Department of Forest Science, Oregon State University; Ruskin Hartley, Save-The-Redwoods League; Redwood Sciences Lab, U.S.D.A. Forest Service-Pacific Southwest Research Station; Six Rivers National Forest, U.S.D.A. Forest Service; Amedee Brickey, Arcata Office of the U.S.D.I. Fish and Wildlife Service.

And of course I need to acknowledge the lean beasts who left little more than paw prints as evidence of their presence, but from which we've begun to understand a bit of their fascinating ecology in the coastal forests of California.

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INTRODUCTION

The American marten (*Martes americana*) is composed of 14 recognized subspecies and is broadly distributed throughout boreal and coastal coniferous forests in North America (Hall 1981). In the western United States the distribution is highly peninsularized, tracking the distribution of coniferous forests on interior (e.g., Rocky Mountains, Cascades, and Sierra Nevadas) and coastal (e.g., Olympic Peninsula, and Oregon and California coast ranges) mountain ranges. The contemporary distribution of American martens has declined from that of pre-settlement period of European peoples (Giblisco 1994) and the most dramatic declines have occurred in the maritime regions of both the Atlantic and Pacific coasts (Bergerud 1969, Dodds and Martell 1971, Giblisco 1994, Zielinski and Golightly 1996, Zielinski et al. 2001). Of the 14 subspecies of American martens recognized by Hall (1981), *M. a. atrata* on the island of Newfoundland has received the most conservation attention and has been designated a red list species by the Canadian Fish and Wildlife Service. Recently, Zielinski et al. (2001) documented a substantial decline in the distribution of another recognized subspecies, the Humboldt marten, (*M. a. humboldtensis*, Grinnell and Dixon 1926). The Humboldt marten is endemic to the coastal forests of northwestern California and was originally described as occurring in “the narrow northwest humid coast strip, chiefly within the redwood belt” from the Oregon border to northern Sonoma county (Grinnell et al. 1937). In the early 1900s the Humboldt marten was already declining due to intense trapping pressure (Grinnell et al. 1937). Despite closure of the trapping season for martens in California in the late 1940s, populations of the Humboldt marten apparently have never recovered. During the same period that efforts were taken to conserve the remaining martens through the cessation of trapping for their fur, the region's primary forests were logged at an accelerating rate (Bolsinger and Waddell 1993). During the 1900's, roughly 95% of the redwood forests were converted from mature and old-growth stands to structurally and compositionally different stands of 80 years or less (Thornburg et al. 2000). Adjacent near-coast coniferous forest types, such as those dominated by Douglas-fir, have undergone a similar pattern of loss of mature and old- growth stands (Bolsinger and Waddell 1993).

Currently there is only one known population of martens that occupies less than 5% of the historical range of the Humboldt subspecies (Zielinski et al. 2001, Slauson et al. 2002). Conservation efforts or management alternatives favoring marten populations are hampered by a lack of information on their habitat ecology and their response to forest management in the coastal forests of California. There have been no investigations of the habitat ecology of the Humboldt marten or within coastal forest habitats occupied by *M. a. caurina* in Oregon or Washington. The only published studies on the habitat ecology of martens in Pacific coastal forests were conducted by Baker (1992) on Vancouver Island, British Columbia and Schumacher (1999) in southeast Alaska.

Habitat selection occurs hierarchically at each of the scales to which a species responds. Individual animals respond to their environment over several spatial scales, with the smallest scale corresponding to the grain of the animal, and the largest scale being at least its home range (Kotliar and Wiens 1990). Different aspects of an animal's life history (e.g., daily resting, winter foraging, finding mates) motivate selection at each of these scales (Bissonette et al. 1997). Investigations of habitat selection must carefully determine which habitat characteristics are important to consider and at what spatial scale they should be measured (Johnson 1980). Multi-scale investigations are generally superior to single-scale investigations because studies conducted over several spatial scales facilitate a greater understanding of how animals assimilate information and make decisions that influence habitat selection (Ritchie 1997). To reach valid conclusions in studies of habitat selection, used habitat characteristics should be compared to available or unused habitat characteristics (Manly et al. 1993). When habitat characteristics are used disproportionate to their availability, use is said to be selective (Manly et al. 1993). The development of an understanding for the characteristics of forest habitats selected by martens at multiple spatial scales in coastal northwestern California can provide a strong foundation from which conservation and management alternatives favoring martens can be developed.

The American marten is considered one of the most habitat-specific mammals in North America (Harris 1984, Buskirk and Ruggiero 1994). Throughout most of their distribution martens are associated with closed-canopy, late-successional stands of mesic conifers with complex structure on or near the ground (Buskirk and Ruggiero 1994, Buskirk and Powell 1994). Martens avoid open areas lacking overhead cover or vertical tree boles that provide vertical escape routes from predators (Drew 1995).

Martens are highly mobile animals and have home ranges that are 3-4 times larger than predicted for a 1 kg terrestrial mammalian carnivore (Buskirk and Ruggiero 1994). Bissonette et al. (1997) demonstrated that martens select habitat at three spatial scales and that a fourth scale operates as an upper-level constraint to habitat selection. These include the micro or sub-stand (several square meters), stand (several hectares), home range (one half to several square kilometers), and landscape scales (tens to hundreds of square kilometers).

At the microhabitat scale, martens select specific habitat features that provide foraging, resting, and denning opportunities. Martens likely choose foraging locations where prey species are abundant and where the habitat structure at the site renders prey vulnerable to capture (Buskirk and Powell 1994). Martens are considered dietary generalists, but show strong seasonal variation with respect to the types of food items taken (Strickland and Douglas 1987, Martin 1994). Martens take advantage of seasonally abundant foods, such as fruits and insects during the summer and fall (Koehler and Hornocker 1977, Simon 1980). Several mammal species including, voles (*Clethrionomys*, *Microtus*), pine squirrels (*Tamaisciurus*.), ground squirrels (*Spermophilus*), and chipmunks (*Tamias*) are important components of the diet of martens in the western United States (Martin 1994). Voles and pine squirrels are most important during the winter months when prey options are most limited (Buskirk and

Ruggiero 1994), and ground squirrels and chipmunks become important during the summer months (Zielinski et al. 1983). This seasonal variation in diet likely results in seasonal variation in the selection of microhabitat for foraging to match that of the prey species.

Martens use rest sites between periods of activity and females use natal dens to give birth to their kits in the spring and later move them to one or more maternal dens until they are old enough to disperse on their own. Martens select structures for resting and denning that will provide both thermal refugia (Taylor 1993) and refugia from predators. Seasonal variation in use of rest structure types occurs, with above-ground structures used more during summer and fall and below-ground or subnivien structures used more during winter (Wilbert 1992, Gilbert et al. 1997, Raphael and Jones 1997, Chapin et al. 1998). Rest structures typically include cavities or platforms in live trees or snags, cavities in logs, and, to a lesser extent, rock piles, slash piles, and subterranean cavities (e.g., those created by rotting root wads) (Raphael and Jones 1997, Gilbert et al. 1997, Ruggiero et al. 1998, Bull and Heater 2000). Den structures typically include arboreal cavities in live trees, snags (Gilbert et al. 1997, Raphael and Jones 1997, Bull and Heater 2000) and logs, rock crevices and red squirrel middens (Ruggiero et al. 1998). Resting and denning sites are most commonly located in woody structures (live trees, snags, logs) that tend to be in the largest available size classes and are used disproportionate to their availability (Wilbert 1992, Gilbert et al. 1997, Raphael and Jones 1997, Ruggiero et al. 1998).

At the stand scale, martens select stands with the structural features that provide for one or more life-history requirements (e.g., prey populations, resting structures). Most studies have found that martens use mid- or late-successional stands of mesic conifers with complex physical structure near the ground and dense canopy closure (Buskirk and Powell 1994). Clear-cut and heavily logged stands generally are not used for several decades following logging, however this varies by location, and is most likely dependent on the time to development of a closed canopy and structural complexity near and on the ground return to the stand (Buskirk and Powell 1994). Two key prey species in the winter diet of martens in the western U.S., red-backed voles (*Clethrionomys californicus* and *C. gapperi*) and Douglas squirrels (*Tamaisciurus douglasii*), are closely associated with elements of late successional forest structure. Both are more abundant in mature coniferous forests, with the former being most closely associated with abundant large diameter downed woody debris and logs (Hayes and Cross 1987, Raphael 1989, Tallmon and Mills 1994) and the latter with cone-producing stages, especially in late-successional stages (Flyger and Gates 1982). Moreover, several studies have found that there are seasonal differences in the ages of stands used by martens, with a selection for older forests during the winter (Buskirk and Ruggiero 1994).

Martens forage over portions of their home ranges sequentially, resting in trees and snags in close proximity to the locations of their foraging areas and most recent kill sites (Marshall 1946, Spencer 1981). Low rates (< 25%) of re-use of rest sites indicate that numerous suitable resting structures need to be available within each individual marten's home range (Raphael and Jones 1997, Zielinski et al. 1996). This, combined with seasonal shift in the use of above- and below-ground resting structures, indicates the need for stands included in marten home ranges to contain multiple suitable resting structures within each structure type (e.g., snags, logs). In western forests, large live trees, snags, and downed logs are most abundant in stands that are in late successional stages.

At the home-range scale, martens position their home ranges to include forest stands that provide for year round life history needs (e.g., seasonal prey bases, access to mates) while avoiding same-sex conspecifics (Katnik et al. 1994). Home range size has been shown to vary depending on prey abundance and habitat type (Soutiere 1979, Thompson and Colgan 1987). Mean home range estimated from reviewed nine studies ranged from 0.8 km^2 to 15.7 km^2 for male martens whereas female martens used home ranges that averaged about one-half that size (Buskirk and McDonald 1989). Home ranges in landscapes with clearcuts can be from 1.5 to 3.1 times greater than those from landscapes without clearcuts (Thompson and Colgan 1987). Katnik (1992) found that in an industrial forest site, martens occupied home ranges that included more mature forest and less clearcut and regenerating forest relative to their availability. In an adjacent forest reserve, where clearcuts and regenerating forest were not present, martens did not exhibit selection at the home-range scale (Chapin et al. 1998). Martens appear to consider habitat heterogeneity, interspersion, and juxtaposition when establishing a home range, but at some threshold suitable habitat becomes too dispersed to be adequate for an individual to maintain a home range that meets its energetic and ecological needs (Bissonette et al. 1997).

At the landscape scale, dispersing individuals select from suitable portions of the landscape unoccupied by same-sex conspecifics to establish home ranges. Loss and fragmentation of mature forest and the resulting changes in landscape pattern constrain animal movement (Bissonette et al.1989, Chapin 1995, Hargis 1996) and demography (Fredrickson 1990, Hargis 1996). Studies conducted in Maine, Utah, and Quebec found that martens appear to avoid landscapes with more than 25-30% of mature forest removed (Bissonette et al. 1997, Potvin et al. 2000). Landscape characteristics, such as distance between small and large patches have been shown to influence the use of patches by martens (Chapin et al. 1998). Phillips (1994) demonstrated that martens used only 33% of the available landscape in the industrial forest site, while they occupied >80% of the landscape in a nearby forest preserve. Marten responses to landscape-level changes in forest area and configuration of mature forest patches have not been previously studied in coastal forests of the Pacific states, despite the fact that most of these forests are currently intensively managed for timber production, with much of the landscape already exceeding the 25-30% mature forest-loss threshold (United States Department of Agriculture 1992, Bolsinger and Waddell 1993, Thornburg et al. 2000).

The purpose of this study is to investigate habitat selection at multiple spatial scales by the only known population of American martens within the historical range of *M. a. humboldtensis*. The objectives of this study are to determine: 1) the microhabitat characteristics at sites used by Humboldt martens, 2) the characteristics of the habitat selected by martens at the stand and home-range scales, and 3) whether the number or proportion of marten detections vary by forest management regime. This study will provide important new information on the habitat ecology of martens within the historical range of the Humboldt subspecies and is the first study of the habitat ecology of martens in the coastal forests of the Pacific states. This information will be important for developing conservation, restoration, and management options that will favor martens in coastal northwestern California.

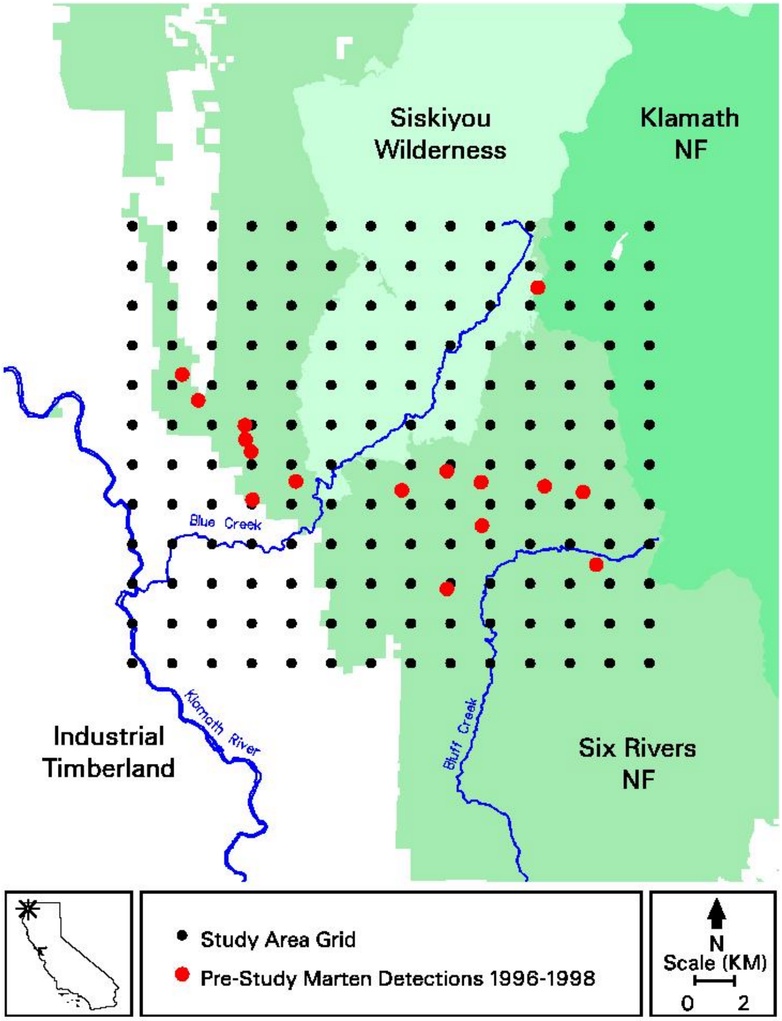
METHODS

Study Area

My study area is approximately 800 km^2 (300 mi^2) and is located in coastal northwestern California (123° 45’ 00’’, 41° 30’ 00’’). It includes portions of southern Del Norte, northern Humboldt, and western Siskiyou counties.
The majority (78.3%) falls within the Smith River National Recreation Area (SMNRA) and the Orleans Ranger District (ORD) of the Six Rivers National Forest and the Ukonom Ranger District (URD) of the Klamath National Forest. The remainder of the study area is within lands owned and managed by the Simpson Timber Company (STC) (Figure 1). There are 4 different management units within the study area: Siskiyou Wilderness (18.2%), National Forest-Late Successional Reserves (39.7%) (USDA 1995), National Forest-matrix (20.2%), and private industrial timberlands (21.7%). Elevation in the study area ranges from about 10 m (33 ft) near the mouth of Blue Creek to 1581 m (5188 ft) at the summit of Peak 8. The study area ranges from 10.9 km (6.8 mi) from the ocean on the western edge to 38.5 km (24.0 mi) on the eastern edge.

The climate is an inland expression of the maritime regime, characterized by moderate temperatures, distinct wet and dry periods throughout the year, and high rainfall during the winter months (Jimerson et al. 1996). Precipitation in the study area comes largely as rainfall, totaling between 200 to 300 cm (80 to 120 inches) annually. Snowfall occurs sporadically during the winter months and rarely persists long on the ground below 900 meters in elevation. Summer fog is

Figure 1. Study area, ownership, preexisting marten detections, and the new sampling grid.



present within the western edge of the study area and moves further eastward within the major stream drainages (e.g., Blue Creek, Goose Creek) providing an important source of moisture for plants during the driest portions of the year.

The study area is in the Klamath-Siskiyou and Northern California Coastal Forest ecoregions (Ricketts et al. 1999). The combination of a strong west-to-east moisture gradient, an elevational gradient, and different soil types influence the distribution of plant communities within the study area. Douglas-fir (*Psuedotsuga menziesii*) associated forest types dominate the study area, with redwood (*Sequoia sempervirens*) types becoming important to the west and white fir (*Abies concolor*) types to the east at upper elevations. The presence of serpentine soil types have fostered several structurally and compositionally unique forest types, hereafter referred to as serpentine habitats, which also harbor a rich diversity of plant species (Kruckeberg 1984). Serpentine habitats have an insular distribution within northwestern California and comprise 13.8% of the study area. Because of low levels of essential nutrients and high concentrations of detrimental elements, serpentine soils offer a harsh growing environment for plants (Jenny 1980). As a result, forest stands growing on serpentine soils are typically open and rocky with slow growing woody plants and often stunted trees (Jimerson et al. 1995). Forest communities growing in the other more productive soil types that are much more common in the region, tend to have closed canopies, larger diameter trees, and have comparably little surface rock (Jimerson et al. 1996).

Following the Potential Natural Vegetation (PNV) classification system of Jimerson et al. (1996), the study area is composed of tanoak (*Lithocarpous densiflora*) series (45%), Douglas-fir series (22%), white fir series (11%), redwood (9%), and other series (13%). Different management histories for portions of the study area have had strong effects on the degree to which the seral stage distribution resembles that of the pre-logging period. STC lands have the most altered seral stage distribution due to extensive logging (>80%), whereas the Siskiyou Wilderness portion of the study area has been unaltered by logging.

Detection Methods

Sampling design

I established a 12 by 14 point grid with 2 km spacing between grid points and a random point of origin for sampling (Figure 1). The grid was designed to extend at least 2 km beyond the outermost locations at which martens were detected during surveys conducted in the region from 1996 to 1999 (Figure 1; Zielinski et al. 2001). The grid spacing was a compromise between maximizing the detection of as many different individuals as possible and covering the largest geographical area possible. The southwestern portion of the grid (5 grid points) fell in the Klamath river and was excluded, resulting in 163 grid points. Five of the original 163 sample units in the Siskiyou wilderness were not sampled due to inaccessibility and one sample unit was added to the grid. Eleven of the 159 sample units completed were moved from their intended grid locations due to either inaccessibility or placement error. Sample unit elevations ranged from 52 to 1457 meters (170 – 4770 ft) with an average of 911 m (SE = 22.5; $\bar{x}$ = 2990 ft, SE = 83.9).

Track plates

I used sooted track plates (Barrett 1983, Zielinski and Kucera 1995) to determine presence of martens at each point on the grid. Each sample unit consisted of two track-plate stations. The first track-plate station was established at the grid point. The second track-plate station was placed 200 meters from the first on a random bearing, but within the stand encompassing the grid point. Stands were defined by vegetation series and seral stage using the classification system of Jimerson et al. (1996). I attempted to place all track plate stations at least 50 meters from the edge of stands, however the irregular shapes of many stands made this impossible in approximately 10% of the stands. Each station was baited with chicken and was checked every other day for 16 consecutive days. A commercial trapping lure (Gusto, Minnesota Trapline Products, Pennock, Minnesota), was placed at each station when it was established and reapplied on the eighth survey day if no marten detection had occurred at the sample unit.

I used systematic sampling to investigate habitat selection for a combination of practical and analytical reasons. At the design phase of this project all that was known was that a small number of haphazardly placed remote camera and track plate stations had detected martens in limited portions of the study area. No previous studies of martens had been conducted within the coastal forests of the Pacific States to help guide design considerations. A systematic grid-based design using track plates allowed sampling of the largest possible area and gave an unbiased sample of the locations and vegetation types where martens were likely to occur. A benefit of this approach over a more intensive telemetry-based approach was that I was likely to include more individuals distributed over a larger sample of the study area in the sample using this approach. This design also allowed me to simultaneously sample locations where martens did and did not occur and is an accepted design for resource selection studies (sampling design I, sampling protocol C, Manly et al. 1993).

Live trapping

I attempted to live-capture martens at every sample unit where they were detected. The objectives of live-capturing individual martens were to gather genetic samples for future analysis and to determine how many individuals are present at samples units where they are detected using track plates. At stations where martens were detected, at the conclusion of the 16-day track session I placed a Tomahawk live-trap (Model 205, 22.8 x 22.8 x 66 cm) in the same location as each track-plate station. Each live-trap was modified with two pieces of masonite covering the wire mesh floor and a wooden cubby box attached to the end opposite the trap door (Wilbert 1992). Both modifications are believed to reduce the chance of injury and stress. Once opened, each trap was checked at least daily for 16 consecutive days. A detailed description of the animal immobilization and handling procedure is in Appendix A. All animal handling procedures were approved by the Oregon State University Institutional Animal Use and Care Committee.

Multi-scale Habitat Classification and Sampling

Microhabitat Scale

I defined the microhabitat scale as the area within 12.5 m radius of each track plate station. A combination of variable-radius plot and transect methods, similar to those used by Zielinski et al. (2000), were used to describe composition and structure of vegetation at each track plate station in each sample unit (Table 1). Topographic

Table 1. Description of the habitat variables measured at the microhabitat scale.

Variable	Description
*CWHR Type	General forest or shrub habitat type using CWHR Classification system
*CWHR Size Class	6 tree size classes, based on mean DBH of dominant overstory layer
*CWHR Canopy	Classes of canopy cover of tree layer
Canopy Cover	Spherical densiometer used to estimate percent canopy closure
Slope	Clinometer used to estimate mean percent slope
Distance to Water	Visually estimated distance to surface water, < or > 100m
Macro Aspect	General aspect of site, 0-360^o
Micro Slope	Visually classified, Draw bottom, Concave slope, Mid Slope, Convex Slope, Ridge Top Slope Position
Over 1-3	Visually classified, 3 most dominant overstory tree species
Under 1-3	Visually classified, 3 most dominant understory tree species
Shrub 1-3	Visually classified, 3 most dominant shrub species
%Shrub	Visually estimated, percent cover for entire layer and for each of 3 most dominant shrub species
Ground cover	Visually estimated, percent cover of rocks, soil, herbs, litter
BA Total	Basal area estimated using a 20 factor prism
BA Conifers	Basal area of conifer trees using a 20 factor prism
BA Hardwoods	Basal area of hardwood trees using a 20 factor prism
BA Snags	Basal area of snags using a 20 factor prism

*CWHR = California Wildlife Habitat Relationships classification system.

variables included elevation, percent slope, macro aspects, topographic position, and presence of surface water within 100m. Basal area was estimated using a 20-factor prism and the trees selected by the prism were used to characterize species diversity, size, and condition class. The tree layer within a 0.49 Ha plot (12.5 m radius) centered prism and the trees selected by the prism were used to characterize species diversity, size, and condition class. Shrub species composition and total shrub cover was also ocularly assessed within the on each track plate station was further described using assessments of the presence of 1 or 2 distinct layers, visual estimation of the most dominant species in each layer, and visual estimates of canopy closure of each layer (maximum canopy closure ≤100%). The total tree canopy closure was measured using a spherical densiometer in each cardinal direction at both ends of each 25 m transect centered on the station, for a total of 16 estimates per station. Each site was classified using to the California Wildlife Habitat Relationships (CWHR) system to determine a habitat type, size class, and canopy cover for the area surrounding each track plate using guidelines by Mayer and Laudenslayer (1988). The CWHR classification system was developed to identify broad-scale existing vegetation types and associated structural classes important to wildlife in California. For forest and shrub dominated habitats, the CWHR system identifies habitat types (e.g., Douglas-fir, montane chaparral), tree or shrub sizes (e.g., tree size 5 = >24” mean DBH, shrub size 4 = decadent shrub with >25% crown decadence), and canopy closure (e.g., dense = 60-100% closure).

Because of significant differences between forest communities on sites with serpentine and non-serpentine soils, I summarized their use by martens separately for the microhabitat scale results. However, for the stand, home-range, and mixed-scale analysis sites with serpentine and non-serpentine soils were analyzed together.

Stand and Home Range Scales

I measured habitat characteristics using GIS for all variables used to develop models of habitat selection for the stand and home range scales. For both scales I used the vegetation coverage developed by the Six Rivers National Forest Ecology Program (EP) during the mid-1990s (see Jimerson et al. 1996). The EP coverage describes the potential natural vegetation communities (PNV) in a hierarchical manner (Allen 1987) consistent with the classification systems of other federal agencies within the United States. The EP classification system was derived from extensive ecological plot sampling of over 1200 plots distributed across the Six Rivers National Forest. The EP vegetation layer was developed through a combination of air photo interpretation, polygon typing based on the classification system, and ground truthing of most polygons. Hereafter I refer to these polygons as stands, differentiated by the combination of their seral stage and existing vegetation type. The STC portion of the study area was not included in the original EP coverage. This area was mapped and added to the EP coverage using the same techniques by the original Six Rivers National Forest mapper in 2001. For analysis at the home-range scale I also used a streams and serpentine soils coverage (Appendix B).

Stand Scale

The stand scale is defined by the size and shape of each stand that encompassed a grid point in the study area. Stands that encompassed grid points ranged from 1 to 137 ha in size ($\bar{x}$ = 24 ha, SD = 23). The explanatory variables included at this scale described structural, compositional, and topographic characteristics of each stand.

Three structural variables (seral stage, tree canopy closure, and shrub cover) were measured at the stand scale (Table 2). I selected the seral stage variable (SERAL) because it describes the stage of stand development and corresponds closely to the level of structural diversity for each stand. Martens shown close association

Table 2. Description of the habitat variables measured at the stand scale.

Variable	Description
SERAL	Seral stage for each stand. There are 6 seral stages: shrub (S), pole (P), early-mature (E), mid-mature (M), late-mature (L), and old growth (O).
TREE_COV	Percent tree canopy closure. Estimated by 5% increments from aerial photographic interpretation.
CONIF	Relative percent conifer cover. Estimated by dividing the percent conifer canopy cover by the percent total (conifer and hardwood) canopy cover for each stand.
SHRUB_C	Percent shrub cover. Estimated for the entire stand by averaging the total percent shrub cover from the two 0.49 Ha plots within each stand.
ASP/MSP	Macro aspect and macro slope position combination. Macro aspect of the stand at one of three macro slope positions (bottom, mid, and upper).

with later seral stages (e.g., Lensink 1953, Cambell 1979, Buskirk 1984, Snyder and Bissonette 1987, Slough 1989, Buskirk and Powell1994) and have several life history needs (foraging, resting, denning) that are directly linked to the presence of large live trees, snags, and logs typically most abundant in the later seral stages. The EP coverage defined 6 seral stages (Shrub, Pole, Early-mature, Mid-mature, Late-mature, Old growth) with up to 4 distinct sub-groups. Sub-groups for seral stages provide information on the logging history as well as the presence of large residual trees. For the analysis I only used the 6 seral stage groups for the SERAL variable. Descriptive variables and log and snag data for each seral stage within dominant vegetation series are provided in Appendix C. I selected tree canopy closure (TREE_COV) because martens require overhead cover and are reluctant to enter areas devoid of it (e.g., Lensink 1953, Bateman 1986, Spencer et al. 1983, Drew 1995). Tree canopy closure was also available in the EP coverage and was visually estimated by 5% increments through interpretation of aerial photographs. I also included total percent shrub cover (SHRUB_C) for each stand because of the importance of this structural layer in coastal forests of northern California. The shrub layer also provides overhead cover and food in the form of fruits and vegetative matter that I hypothesized would be important to martens and their prey. Shrub patches have been shown to be important for martens as foraging areas (Magoun and Vernam 1986, Martin 1987). Information on the shrub layer was not available from the EP coverage but was estimated for each stand by taking the mean of the two plot level 0.49 ha estimates for each stand to generate an index of total shrub cover for the stand. In general, the characteristics of the shrub layer within a stand were fairly uniform and their presence and vigor is directly related to the canopy characteristics and site conditions of the stand (pers. obs.). Therefore, the combination of the two 0.49 ha plot level estimates of shrub cover should represent a good index of shrub cover for the stand. I included relative conifer composition (CONIF) for each stand because martens have been shown to be positively associated with conifer-dominated stands (e.g., Simon 1980, Cambell 1979, Spencer et al. 1983, Bateman 1986, Katnik 1992) and negatively associated with hardwood stands (Thomasma 1996). Relative conifer composition was estimated by dividing percent canopy closure of conifer by percent canopy closure of all trees; both values were available in the EP coverage. The CONIF variable was a better representation of the tree species composition (coniferous or hardwood species) for the stand than using either the PNV series or series-subseries also available in the EP coverage. I used a single topographic variable (ASP/MSP) to describe the importance of macro-aspect relative to three possible slope positions (bottom, mid, and upper slope positions). This was chosen because the combination of slope position and macro-aspect has a strong influence on the microclimate conditions and ultimately the productivity found within each stand. I hypothesized that martens select stands in the most mesic slope-aspect positions. Stands at mid slope positions and north-facing aspects are the most mesic, stands at bottom slope positions are typically uniformly mesic due to their proximity to streams, and stands on upper slope positions are typically more xeric regardless of macro-aspect.

Home-range Scale

I defined the home-range scale as the area within 1 km (314 ha) of each point on the grid, an area slightly smaller than the mean home range sizes estimated for 6 male (388 ha) and 5 female (324 ha) martens in the northern Sierra Nevada mountains (Simon 1980, Spencer 1981). Although a 1-km radius circle covers a similar area as the average size of a marten home range, it will probably not have the same habitat composition as actual home ranges. However 1-km radius circles provide an opportunity to investigate home-range scale characteristics associated with locations where martens are and are not detected.

Explanatory variables at the home-range scale include compositional, spatial arrangement, and management-related variables (Table 3). Four compositional variables were measured at the home-range scale: total area in the old-growth seral stage, in the old-growth and late-mature seral stages, and in serpentine soil types, and total linear distance of streams. I chose to use two versions of seral stage composition variables because I was interested in whether the oldest seral stage (old growth) or the combination of the two oldest seral stages (old-growth and late-mature) was more important for martens. Later seral stages comprised major portions of marten home ranges in three studies (Wilbert 1992, Chapin et al. 1998, Phillips 1994). I selected the serpentine soil type variable (SERP) as a surrogate for total amount of forest habitat whose structure and composition is determined by the presence of these harsh soil types. I hypothesized that these unique habitat types were important for martens in particular portions of the study area where they occur, and that larger amounts of

Table 3. Description of the habitat variables measured within 1-km radius circles around each grid point.

Variable	Description
OG_COMP	Area (ha) of old-growth seral stage.
OLM_COMP	Area (ha) of old-growth and late-mature seral stages.
SERP	Area (ha) of serpentine soils types. This is a surrogate for the amount of serpentine habitat.
STREAM	Sum of the linear distance of streams. This is a surrogate for riparian habitat.
OG_PATCH	Area (ha) of the largest contiguous patch composed of old-growth seral stage.
OLM_PATCH	Area (ha) of the largest contiguous patch composed of both old-growth and late-mature seral stages.
LOGGED	Percent area that has been logged. Clearcutting was the dominant silvicultural method in the study area, thus all types of logging were lumped for this variable. All logged stands were typically <50 years old and included post logging stands mostly in the shrub, pole, and early-mature stages.

these habitat types increase suitability of the site for martens. I chose the STREAM variable as a surrogate for riparian habitat. Two studies demonstrated that riparian areas are important for foraging sites and harbor important resting structures (Spencer et al. 1983, Raphael and Jones 1997). I selected two spatial arrangement variables, the area of the largest contiguous patch composed entirely of the old-growth seral stage (OG_PATCH) and the area of the largest contiguous patch composed of the old-growth plus late-mature seral stages (OLM_PATCH). Chapin et al. (1998) found that marten home ranges contained significantly larger maximum patch sizes of mature forest than would be expected by chance. I measured a single variable related to management, the total percentage of the 1-km radius circle that had been logged (LOGGED). I included this variable because martens have been shown to have negative associations with logging at the home-range scale (Campbell 1979, Fredrickson 1990, Thompson and Colgan 1994, Paragi et al. 1996, Chapin et al. 1998). Clearcutting was the dominant silvicultural method in the study area and for the LOGGED variable I combined all areas that had been logged together. The majority of stands that had been logged within the study area were typically <50 years old.

Mixed Scale

To investigate the importance of variables at both spatial scales I developed a set of mixed-scale models which had at least one variable from both the stand and home-range scales. The objective of including mixed-scale models is to investigate whether the probability that a marten will select a site is more dependent on the combination of variables from different scales than from variables at a single scale.

Management Unit

Within my study area the intensity with which logging has impacted the pattern of distribution and abundance of late-successional forest varies depends on the past and current management goals of the owner (STC) or administrator (USFS) of the land. I partitioned the study area into four management units, Private Industrial Timberlands

(PIT), U.S. Forest Service Matrix (FSM), U.S. Forest Service Late-successional Reserves (LSR), and U. S. Forest Service Wilderness (WILD). These represent a gradient of past logging intensity, from no logging in the WILD unit, low levels in the FSM (16%) and LSR (13%) units, and a high level (83%) on the PIT unit (Figure 2). These four units also differ in their vegetation series compositions (Figure 3).

Figure 2. Relative composition of old growth, serpentine and percent logged area for each management unit.

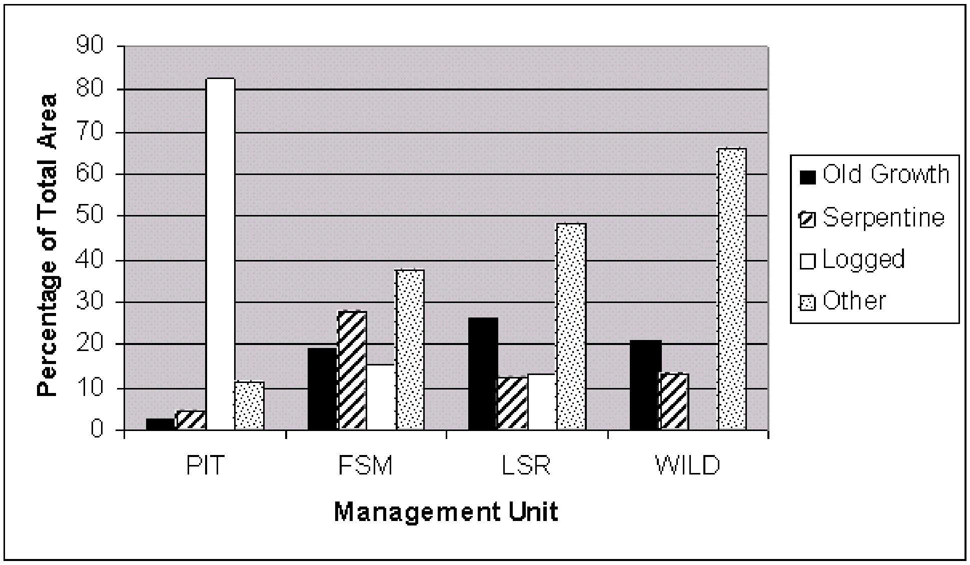
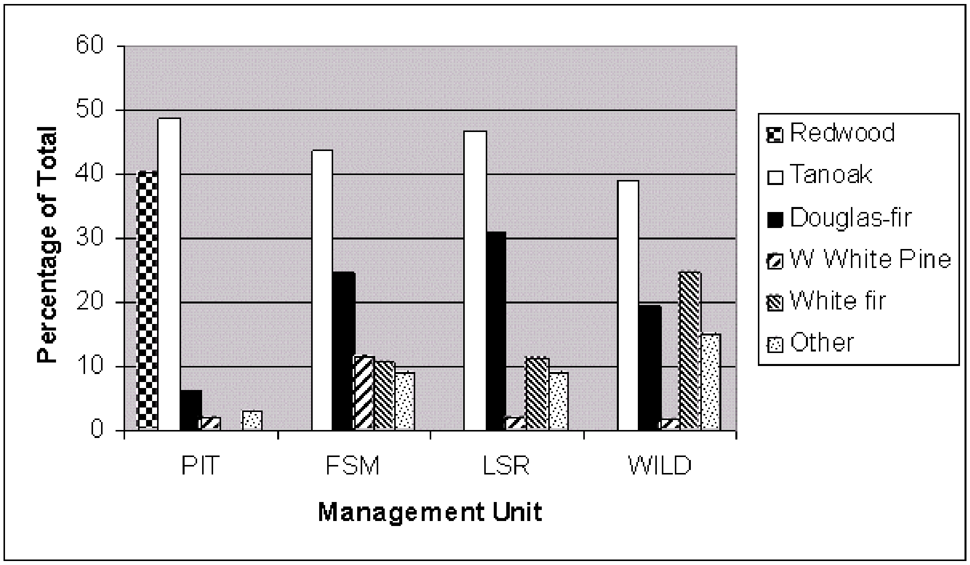


Figure 3. Relative vegetation series composition for each management unit.



Statistical Analysis

Microhabitat Analysis

I compared microhabitat characteristics between stations where martens were and were not detected using descriptive statistics. I compared categorical variables using rank sums and continuous variables using means and their standard errors. Results for CWHR classification for each station where martens were detected are presented in Appendix D.

Stand, Home-Range, and Mixed-Scale Analysis

For stand, home-range, and mixed-scale analyses a sample unit was considered used if a marten detection occurred at one or both stations within the sample unit. I used resource selection functions (Manly et al. 2002) to investigate habitat selection at the stand, home-range, and mixed-scales. In this study, used and unused resources were identified at the population level, and a random sample of each was simultaneously collected. This conforms to sampling design I, sampling protocol C in Manly et al. (1993) and involved estimating resource selection probability functions (RSPF). This analysis assumes that the probability of a marten visiting a track plate sample unit is constant across all sample units and that if a marten home range includes a track plate sample unit there is a high probability that the marten will visit it, given it is present for a sufficient period of time. Detection uncertainty was evaluated using a maximum likelihood estimate of the probability that a marten will be detected using the 2-station per stand, 16-day, 8 visit protocol in this study (Zielinski and Baldwin unpubl. data).

Due to use of prospective sampling and a response variable with a binomial distribution (marten present or absent) , the RSPF conforms to standard logistic regression. The mathematical model for the RSPF takes the form:

$$W_{(x)} = \frac{\exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_n x_n)}{1 + \exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_n x_n)}$$

where $W_{(x)}$ is the predicted probability of resource use for the given combination of covariates (X_i), and slopes (β_1), and the intercept (β_0) are maximum likelihood estimates.

I used PROC GENMOD (SAS Institute 1999) to estimate RSPF’s to determine the probability of resource selection of forest characteristics measured at two spatial scales (stand and home-range).

For the stand, home-range, and mixed-scale analysis I used an information-theoretic method of data analysis, which is based on Kullback-Leibler information, an equation describing the information lost when a model is used to approximate truth (Burnham and Anderson 1998). This method involves development of a small set of *a priori* models based on the careful consideration of biological information. I used a two-stage approach to limit the number of variables included in model development and guide the development of individual models for each spatial scale.

First, I reviewed 29 published studies on the habitat ecology of American martens to determine a set of characteristics that are likely to be important in determining the use or selection of a site at the stand and home range scales. I then added variables that I hypothesized to have unique ecological importance to martens in the study region. Second to limit the number of variables, and thus the number of candidate models, each potential variable was screened using five criteria (Table 4). Variables that did not meet these criteria were excluded from further consideration.

All variables meeting the screening criteria were used to develop competing models representing alternative hypotheses for habitat selection at each spatial scale. The first stage in this process involved the development of conceptual models describing marten habitat selection based on existing information and my own hypotheses about habitat selection in coastal forests of northwestern California.

Table 4. Variable screening criteria.

1. The variable is relevant to the study region and coastal forest types of northwestern California.
2. The variable is easy to measure, has a high level of precision, and was measured in the field or is available in existing GIS coverages.
3. The variable is clearly interpretable and of likely biological importance to martens.
4. The variable was identified to be important in a previously published study on martens or hypothesized to be an important characteristics of coastal forests in the study region.
5. The variable is evaluated at the appropriate scale given the study design and scales used for this study.

Conceptual models were then translated into logistic regression models using the selected variables for each scale. The resulting models sets represented competing hypotheses about scale-specific characteristics that drive marten habitat selection. During model development I limited the total number of variables per model to 4 to maintain interpretability of the results for each variable. I also constrained the number of parameters per model to ≤ 15, to allow a minimum of 10 observations per variable and to maintain interpretability of the process involved. Most models had fewer than 10 parameters.

I ranked each set of models from the stand, home-range, and mixed-spatial scales separately using Akaike's Information Criterion (AIC, Appendix E). AIC is an equation that estimates Kullback-Liebler information. AIC has two components, one that assesses lack of fit and a second that penalizes for each additional parameter by increasing the AIC value. Therefore, when comparing a set of candidate models, models with the lowest AIC values provide strongest inference given the data and the set of *a priori* models (Anderson et al. 2000). I used the Akaike's information criterion for small sample sizes, AICc, recommended for use when the sample size divided the total number of parameters is <40 (Burnham and Anderson 1998).

Models were interpreted by the comparison of ΔAIC_c values, where

$$\Delta AIC_c = AIC_c - \text{minimum } AIC_c$$

Using ΔAIC_c values provides a measure of strength of evidence and a scaled ranking for candidate models (Anderson et al. 2000). Models with $\Delta AIC_c < 2$ are strongly supported and should be considered when making inferences about the data. Models with ΔAIC_c values between 2 and 7 have less support, and those with $\Delta AIC_c > 10$ have little or no support (Burnham and Anderson 1998).

To further interpret the relative importance of a model, given the *a priori* model set, Akaike's weights (w) are used. ΔAIC_c values are used to compute w_i, which is considered the weight of evidence in favor of a model being the best approximating model given the model set (Burnham and Anderson 2001). Unless the model with the lowest AIC_c value has a w_i of >0.9, then other models should be considered when drawing inferences about the data (Burnham and Anderson 1998). I created a 95% confidence set of models by summing all the w_i until 0.95 is reached. w_i can also be used to assess the relative importance of each variable by summing normalized w_i values for every model in which the variable appears (Anderson et al. 2001). Because of the differences in the numbers of models in which different variables occurred, I calculated the adjusted importance weights of all parameters using the formula:

$$\text{Adjusted } w_i = (\#\text{models} * w_i) / ((\#\text{models with variable}) * (\text{total } \#\text{variables}))$$

A null model that only included an intercept term was included to assess if the variables considered were relevant to the data. For models at the stand (15 models), home-range (25 models), and mixed (15 models) scales and the null model I calculated AIC_c, ΔAIC_c, and w_i. I also calculated relative weights for individual parameters. Because I considered more than one model when making inferences about the data I also assessed the importance and interpretation of each parameter by examining the range and direction of response of coefficient values for parameters in the best models for each spatial scale.

To evaluate the performance of the models, I used the best model for each spatial scale to assess the classification success of the original 159 sample units. This assessment provides a diagnostic tool to determine how well each model distinguishes between sites where marten were and were not detected using the original data. It does not represent a model validation effort.

Management Unit Comparison

I used Chi-squared tests to compare the differences between the proportions of sample units where martens were detected on private industrial timberlands (PIT) and all U.S. Forest Service lands (USFS) as well as for U. S. Forest Service matrix (FSM) and reserves (FSR). FSR represents both U. S. Forest Service wilderness and late-successional reserves.

RESULTS

Sample Unit Results

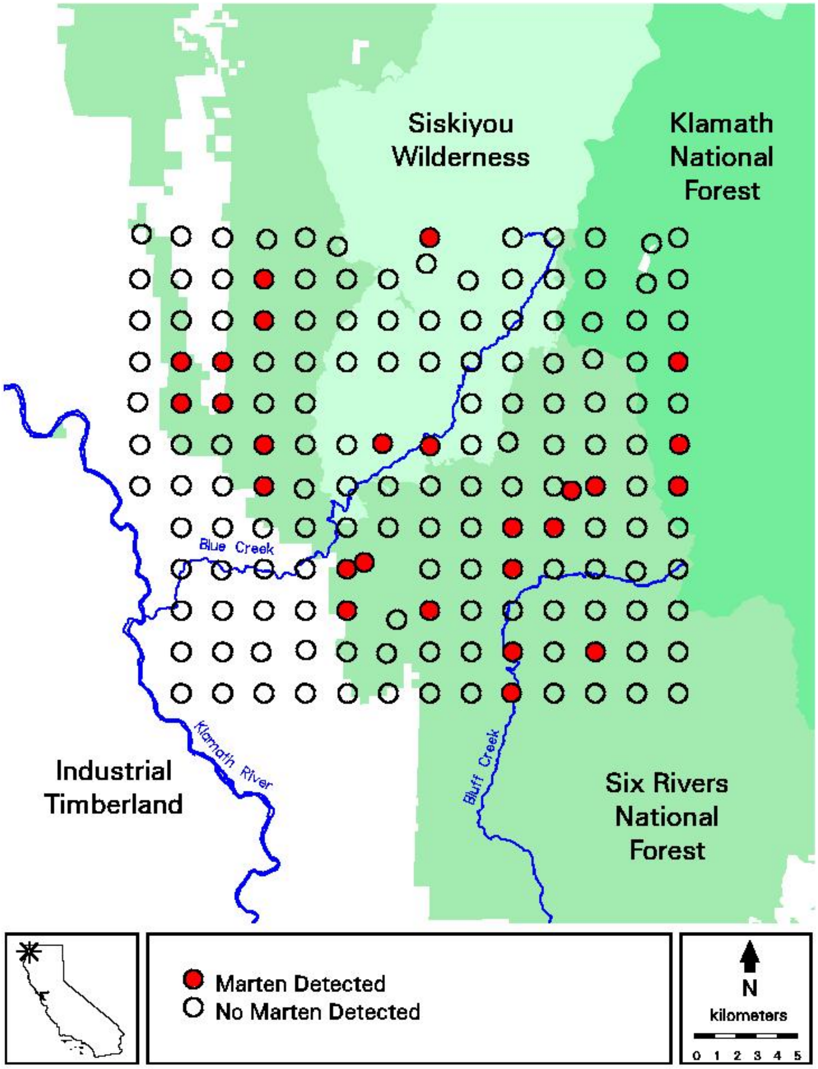
In 2000 and 2001 I sampled 159 sample units within the study grid (Figure 4). American martens were detected at 26 (16.3%) of the sample units (Figure 4). Mean latency to first detection at the sample units was 9.1 days (SE = 3.2; range = 2 to16). Martens were detected at both stations of a sample unit at 8 of 26 sample units. Martens were detected in 2 sample units on private timberlands and 24 on lands administered by the U. S. Forest Service; 7 on the Smith River National Recreation Area, 3 on the Ukonom Ranger District, and 14 on the Orleans Ranger District.

The mean probability of detecting a marten at a sample unit, given that one was present within the sample unit and the sampling design and survey protocol used in this study, was 88% (95% C.I. = 64 – 97%; Zielinski and Baldwin unpubl. data).

Live Trapping

Live-traps were established at 18 of the 26 sample units where martens were detected. Eight sample units were not trapped due to logistical constraints. Fourteen martens (8M : 6F) were captured at 10 of the 18 units. Martens were captured after a mean latency of 5.2 days (SE = 1.0; range = 1 to 16). The highest latency to first capture values were for the three martens that were the second individuals captured at their trap site; the latency to the first marten capture for each sample unit was 3.1 days (SE = 0.6; range = 1 to 8). No martens captured in 2000 were recaptured, however 3 animals captured in 2001 were recaptured in 2001. No individual martens were trapped at more than one sample unit.

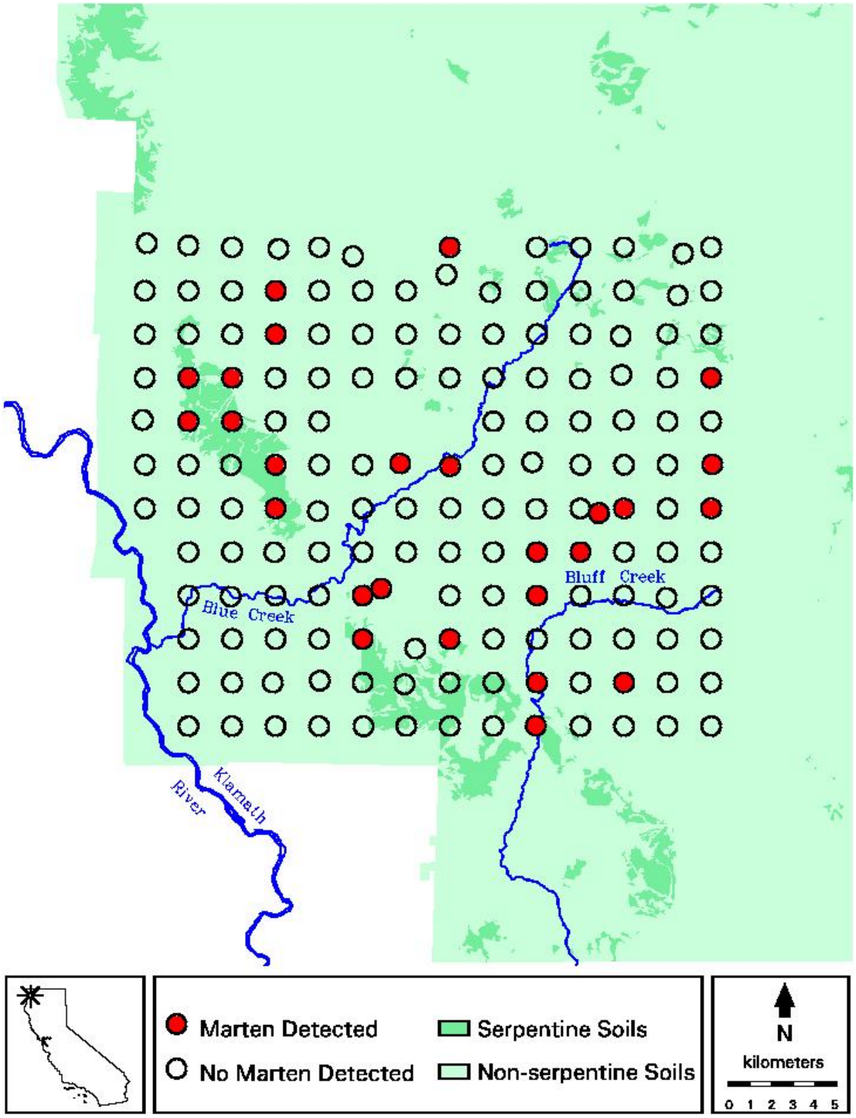
Figure 4. Sample units completed and marten detections within the study grid.



Multi-scale Habitat Analysis

Martens were detected at 8 sample units (10 stations) located on serpentine soils and at 18 sample units (24 stations) located on non-serpentine soil types (Figure 5). Non-serpentine stations where martens were detected ranged from 456 to 1166 meters

Figure 5. Marten detection results and the distribution of serpentine and non-serpentine habitats.



and had an average elevation of 848 m (SE = 12.4). Serpentine stations where martens were detected ranged from 440 to 1196 meters and had an average elevation of 1091 m (SD = 33.5).

Microhabitat Scale

The mean percent slope for microhabitat sites where martens were ($\bar{x}$ = 47%, SE = 4.2) and were not ($\bar{x}$ = 52%, SE = 1.3) detected were similar. Of the 5 possible slope positions, most microhabitat sites were located in mid-slope positions (253), with the draw bottom, concave, ridge top, and convex positions found at 14, 11, 12, and 18 sites respectively (Table 5). Martens were most often detected at sites in mid slope positions (27), however this was the most frequently sampled slope position.

Table 5. Micro-slope position for each track plate station.

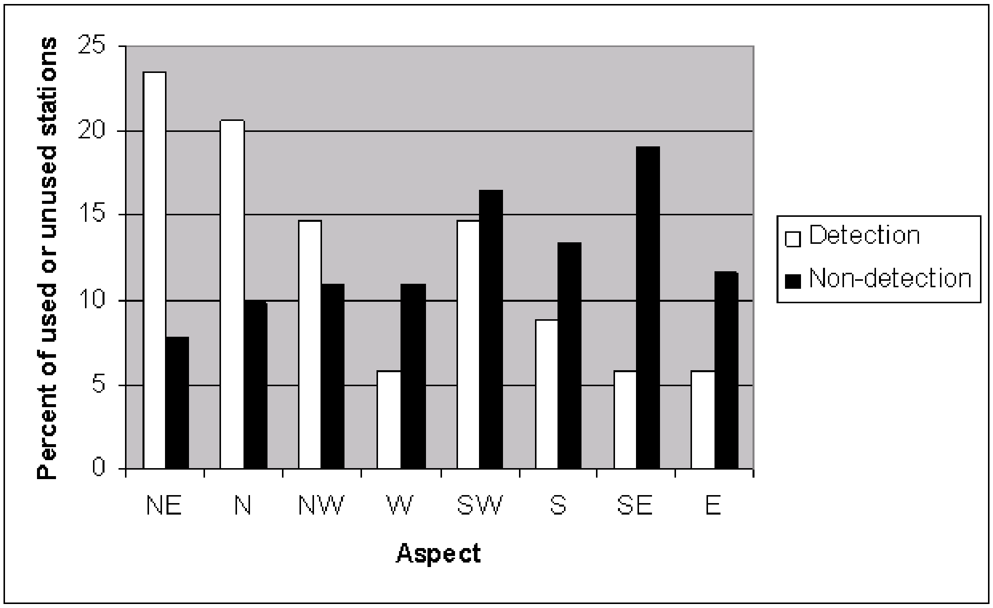
Micro-slope	Non-Detections		Marten Detections	
Position	Non-serpentine	Serpentine	Non-serpentine	Serpentine
Ridge Top	11	0	0	1
Convex Slope	14	1	0	3
Mid-slope	223	15	21	6
Concave slope	9	1	1	0
Draw bottom	10	2	2	0

Marten detections occurred most frequently at mesic microhabitat sites within the study area. Twenty-two of 34 stations where martens were detected were in the most mesic macro-aspect positions (Table 6, Figure 6). Martens were detected proportionately higher at sites <100 from surface water (15 of 34, 44.1%) relative to

Table 6. Macro-aspect for each track plate station.

Micro-slope Position	Non-Detections Non-serpentine	Serpentine	Marten Detections Non-serpentine	Serpentine
Mesic				
NW 270-360°	47	4	6	1
NE 0 to 90°	51	7	10	5
Xeric				
SW 181 to 270°	75	2	5	2
SE 91 to 180°	92	6	3	2

Figure 6. Proportions of stations with and without marten detections in 8 macro-aspect categories.



their availability (106 of 318, 33.3%) and proportionately lower at sites >100 m from water (19 of 34, 55.8%) relative to their availability (212 of 318, 66.6%).

Tree canopy closure at non-serpentine sites where martens were ($\bar{x}$ = 94.5%, SE = 1.2) and were not ($\bar{x}$ = 88.6%, SE = 3.0) detected was similar. In contrast, serpentine sites where martens were detected had a lower mean tree canopy closure ($\bar{x}$ =31.0%, SE = 8.2) than serpentine sites where they were not detected (61.5% (SE = 61.5%; Table 7). A total of 254 of the 318 sampled sites and 26 of the 34 sites where martens were detected had two distinct tree layers.

Douglas-fir was the most, and the second most, dominant overstory species at 22 and 6 sites where martens were detected, respectively (Table 8). Port-Orford cedar was the dominant, and the second most dominant overstory species at 2 and 3 non-serpentine detection sites, respectively. Douglas-fir and western white pine were the dominant tree layer species at all four of the serpentine sites with a distinct tree layer.

Table 7. Canopy closure means for all used and unused stations. Standard errors are in parenthesis.

Tree Canopy	Non-Detections		Marten Detections	
Closure	Non-serpentine	Serpentine	Non-serpentine	Serpentine
Total	88.6% (1.1)	61.5% (6.9)	94.5% (1.2)	31.0% (8.2)
Overstory	43.0% (1.5)	26.3% (4.9)	39.8% (4.2)	19.1% (5.0)
Understory	28.0% (1.4)	21.6% (3.5)	39.4% (4.4)	*

*Only 2 serpentine stations where martens were detected had 2 distinct tree layers.

Tanoak was the most dominant, and the second most, dominant understory tree species at 14 and 4 sites, respectively. Chinquapin was the dominant or second dominant at 4 and 2 sites, while Port-Orford cedar was the dominant or the second dominant understory tree species at 3 and 3 sites, respectively.

Table 8. Declining rank-order tree species dominance for 0.49 Ha plots where martens were detected. For each species the sum of the ranks and the number of sites it was present at, in parenthesis, are presented.

	Non-serpentine (n=24)	Serpentine (n=10)
*Overstory		
Douglas-fir	61 (22)	13 (5)
Port-Orford Cedar	13 (6)	
Tanoak	7 (4)	
Western White Pine		12 (4)
Knobcone Pine		7 (3)
Sugar Pine		6 (2)
**Understory		
Tanoak	36 (13)	
Douglas-fir	16 (9)	
Chinquapin	14 (8)	
Bigleaf maple	11 (5)	
Port-Orford cedar	10 (4)	

*Present in non-serpentine overstory but with ≤6 ranks or occurring at ≤4 sites: Western Hemlock, Sugar Pine, Red fir, Brewer's Spruce, Incense cedar, Jeffrey pine, Chinquapin, Bigleaf maple. Present in serpentine overstory but with ≤3 ranks or occurring at ≤2 sites: Lodgepole pine.

**Present in non-serpentine understory but with ≤3 ranks or occurring at ≤2 sites: Western Hemlock, Sugar Pine, Red fir, Brewer's Spruce, Incense cedar, Jeffrey pine, Canyon live-oak, Red alder, California bay, and Pacific madrone. Present in serpentine understory but with ≤3 ranks or occurring at1 site: Douglas-fir, Lodgepole pine, Tanoak, Canyon live-oak, Pacific madrone.

Mean basal area was similar at non-serpentine stations where martens were detected ($\bar{x}$ = 42.4 m^2 / ha, SE = 3.4) than at stations where they were not detected ($\bar{x}$ = 47.9 m^2 / ha, SE = 7.5) (Table 9). Mean basal area was much lower at serpentine stations where martens were detected ($\bar{x}$ = 19.1 m^2 / ha, SE = 4.1) than at serpentine stations where martens were not detected ($\bar{x}$ = 34.6 m^2 / ha, SE = 4.6) and at all non-serpentine sites (Table 9). The mean basal area of snags was higher at non-serpentine sites where martens were detected ($\bar{x}$ = 5.8 m^2 / ha, SE = 1.8) than at stations where martens were not detected ($\bar{x}$ = 3.4 m^2 / ha, SE = 0.2) and serpentine stations where martens were ($\bar{x}$ = 3.0 m^2 / ha, SE = 0.9) and were not ($\bar{x}$ = 2.7 m^2 / ha, SE = 1.3).

Table 9. Basal area (m^2 / ha) estimated using a 20-factor prism, with each track plate station as plot center. Standard errors are in parenthesis.

Basal Area	Non-Detections		Marten Detections	
	Non-serpentine	Serpentine	Non-serpentine	Serpentine
Total	47.9 (1.4)	34.6 (4.6)	42.4 (3.4)	19.1 (4.1)
Conifer	29.8 (1.2)	31.8 (4.3)	23.5 (3.8)	16.0 (3.1)
Hardwood	14.7 (1.2)	0 (0)	13.2 (2.2)	0 (0)
Snags	3.4 (0.2)	2.7 (1.3)	5.8 (1.8)	3.0 (0.9)

The mean diameter at breast height (dbh) for conifer snags at non-serpentine stations where martens were detected ($\bar{x}$ = 77 cm, SE = 6.6) was slightly higher than at stations where martens were not detected ($\bar{x}$ = 66 cm, SE = 3.3; Table 10). The mean diameter at breast height (dbh) for conifer snags at serpentine sites where martens were detected was lower ($\bar{x}$ = 26.0 cm, SE = 6.5) than serpentine sites where martens were not detected ($\bar{x}$ = 59.5 cm, SE = 19.1).

Table 10. Number of snags included in the 20-factor prism sample and their mean diameters at breast height (dbh). Standard errors are in parenthesis.

Snags	Non-Detections		Marten Detections	
	Non-serpentine	Serpentine	Non-serpentine	Serpentine
Conifer				
Number	221	13	32	4
Mean DBH	68.5 (2.9)	59.5 (19.1)	83.8 (6.5)	26.0 (6.5)
Hardwood				
Number	33	0	5	0
Mean DBH	24.0 (3.4)	0	39.2 (4.0)	0

The mean percent shrub cover for non-serpentine sites was higher where martens were detected ($\bar{x}$ = 75.5%, SE = 4.1) than non-serpentine sites where martens were not detected ($\bar{x}$ = 49.5%, SE = 1.8). Mean shrub cover at serpentine sites where martens were ($\bar{x}$ = 83.3%, SE = 2.5) and were not detected ($\bar{x}$ = 80.2%, SE = 2.9) was similar. In descending rank-order, evergreen huckleberry, salal, rhododendron, tanoak, and Oregon grape were the five most common shrub layer species across all non- serpentine sites where martens were detected (Table 11). For serpentine sites only, huckleberry oak, dwarf tanbark, and evergreen huckleberry were the most dominant shrub layer species.

Table 11. Rank-order shrub species dominance for 0.49 Ha plots where martens were detected. For each species the sum of the ranks and the number of sites it was present, in parenthesis, are presented.

*Shrub Species	Non-serpentine (n=24)	Serpentine (n=10)
Evergreen huckleberry	27 (11)	8 (3)
Salal	27 (10)	
Rhododendron	19 (9)	
Tanoak	14 (6)	
Huckleberry oak		17 (6)
Dwarf tanbark		11 (5)
Oregon grape	12 (8)	
Vine maple	9 (4)	

*Present in non-serpentine shrub layers but with ≤6 ranks or occurring at ≤4 sites: California hazelnut, Thin-leaf huckleberry, California red huckleberry, Oceanspray, Saddler oak, Pinemat manzanita, Pacific dogwood, Western azalea, Huckleberry oak, White-leaf manzanita. Present at serpentine shrub layers but with ≤4 ranks or occurring at ≤3 sites: California hazelnut, California red huckleberry, Oceanspray, Pinemat manzanita, Dwarf California bay, Western Coffeeberry, California hazelnut, Oregon grape, Rhododendron, and White-leaf manzanita.

The only notable difference for any ground cover value was that percent surface rock was much higher at all serpentine sites than at all non-serpentine sites (Table 12) and it was higher at serpentine sites where martens were detected ($\bar{x}$ =

27.5%, SE = 3.4) than at serpentine sites where martens were not detected ($\bar{x}$ = 17.1%, SE = 3.3).

In summary, at the microhabitat scale, marten detections were associated with characteristics of the topographic position, vegetation structure, and ground cover (Table 13).

Table 12. Mean percent ground cover values for microhabitat (0.49 ha) plots centered on track plate stations. Standard errors are in parenthesis.

Ground Cover Type	Non-Detections		Marten detections	
	Non-serpentine	Serpentine	Non-serpentine	Serpentine
Litter	72.4 (1.3)	64.7 (4.5)	76.2 (5.1)	54.1 (3.4)
Herb	19.1 (20)	21.3 (4.2)	19.8 (3.8)	16.6 (2.5)
Rock	6.6 (0.8)	17.1 (3.3)	2.8 (3.2)	27.5 (3.4)
Soil	1.4 (0.6)	1.0 (0.8)	1.0 (1.0)	1.6 (1.2)

Table 13. Summary of variables characterizing sites where martens were detected at the microhabitat scale. All variables listed represent those with large differences between sites where martens were and were not detected.

Variable	Non-serpentine	Serpentine
Macro-aspect	Mesic Aspects	
Tree Canopy Cover		Lower
Understory Tree Cover	Higher	Absent
Shrub Cover	Higher	
Rock Cover		Higher
BA Snags	Higher	
Snag Diameter	Larger	

Stand Scale

Stand scale habitat selection was evaluated by comparing the relative fit of multivariate models. The model with the lowest ΔAIC_c value (Model 1, Table 14) contained the three variables with the highest importance weights (Table 15), shrub

Table 14. RSPFs at the stand scale are presented, the dashed line indicates the end of the 95% confidence set. X's indicate that a variable is included within a model. K represents the number of parameters in a model.

	Variable								
RSPF #	Seral Stage	Shrub Cover	Relative % Conifer	Tree Canopy Cover	Slope Position / Aspect	K	ΔAIC_c	w	Relative Weight
1	X	X	X			8	0.00	0.535	1.00
2	X	X				7	1.68	0.230	2.32
3	X	X		X		8	2.63	0.143	3.74
4	X	X			X	11	4.41	0.059	9.06
5	X	X			X	10	6.50	0.020	26.7
6		X				2	9.98	0.003	178.3
7		X		X		3	10.62	0.002	276.5
8	X		X	X		8	11.34	0.001	535.0
9	X		X		X	10	11.77	0.001	535.0
10		X			X	5	15.21	0.000	>535.0
11	X					6	15.09	0.000	>535.0
12		X	X		X	6	16.00	0.000	>535.0
13	X				X	9	18.17	0.000	>535.0
14			X	X		3	29.97	0.000	>535.0
15			X		X	5	30.63	0.000	>535.0
Null						1	30.99	0.000	>535.0

cover, seral stage, and percent relative conifer composition. This model was 2.32 times more likely than the model with the next lowest ΔAIC_c value (Model 2, Table 14). All four models within the 95% confidence set had both the shrub cover and seral stage variables, which also had the highest importance weights (Table 15). The odds of marten occurrence increased with an increase in shrub cover and an increase in relative conifer composition and within certain seral stages (Table 16). Specifically, a 10% increase in shrub cover was associated with a 43% increase in marten occurrence (odds = 1.43, 95% CI = 1.13 to 1.81), after accounting for seral stage and relative conifer composition. A 10% increase in relative conifer composition was associated with a 27% increase in marten occurrence (odds = 1.27, 95% CI = 0.98 to 1.64), after accounting for seral stage and shrub cover. Relative to the old growth seral stage, the shrub seral stage was associated with a 21% increase (odds ratio = 1.21, 95% CI 0.21 to 7.05), the pole stage an 89% decrease (odds ratio = 0.11, 95% CI 0.02 to 0.66), the early-mature stage a 92% decrease (odds ratio = 0.08, 95% CI = 0.009 to 0.87), the mid-mature a 96% decrease (odds ratio = 0.048, 95% CI = 0.008 to 0.27), and the late-mature stage an 81% decrease in marten occurrence after accounting for shrub cover and relative conifer composition (Table 16). Shrub cover and percent relative conifer

Table 15. Normalized importance weights for stand scale variables.

Shrub Cover	0.199
Seral Stage	0.169
Relative Percent Conifer	0.119
Tree Canopy Cover	0.029
Slope Position / Aspect	0.016

Table 16. Coefficients and odds ratios for the variables in the best stand model (Model 1, Table 14).

Variable	Estimate	95% CL	Odds ratio*
Shrub Cover	0.036	0.01 to 0.06	1.43
Relative % Conifer	2.411	0.01 to 5.22	1.27
Intercept	-4.360	-7.13 to -2.05	
Seral Stage			
Shrub	0.198	-1.58 to 1.99	1.21
Pole	-2.166	-4.21 to -0.55	0.11
Early-mature	-2.447	-5.49 to -0.45	0.08
Mid-mature	-3.040	-5.08 to -1.44	0.04
Late-mature	-1.635	-3.13 to -0.25	0.19
Old Growth	Reference		

*Odds ratios are based on 10% increase in the continuous variables shrub cover and relative conifer composition.

composition were similar for both serpentine and non-serpentine stands (Appendix F). Selection patterns for seral stages differed between non-serpentine and serpentine stands. In non-serpentine stands martens appear to use the old growth seral stage highly disproportionate to availability, used late-mature stage similar to availability and made little or no use of all other seral stages (Figure 7). Although sample size is small for serpentine sites used by martens (n= 8), the shrub and old growth seral stages were used disproportionate to availability, however every seral stage except the pole stage was used at least once (Figure 8).

Classification success using the best stand model (Model 1, Table 14) is presented in Figure 9.

Figure 7. Use and availability of seral stages for non-serpentine stands where martens were and were not detected.

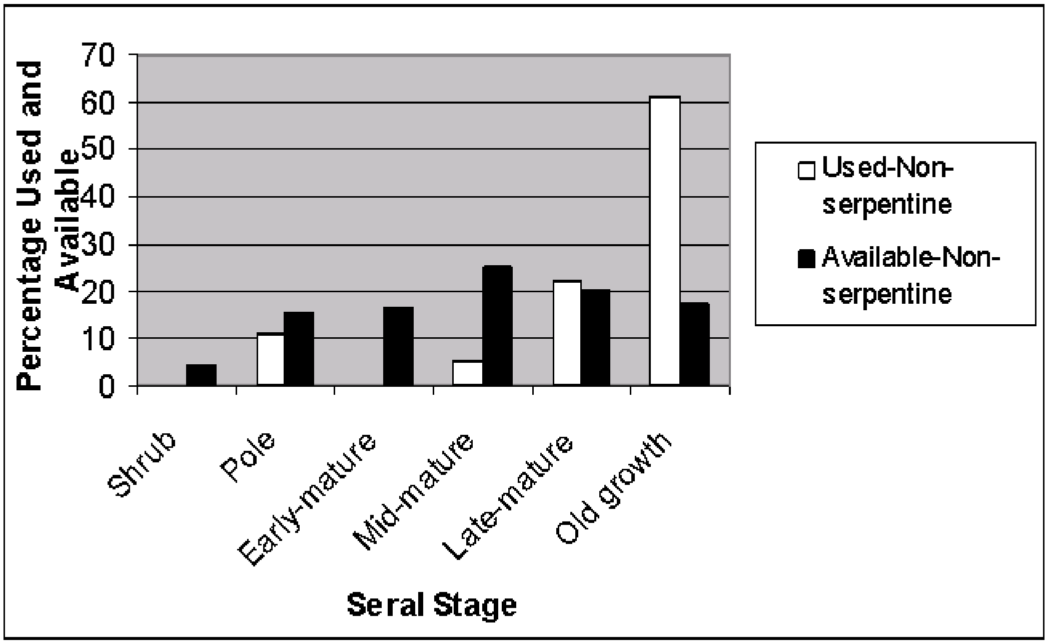


Figure 8. Use and availability of seral stages for serpentine stands where martens were and were not detected.

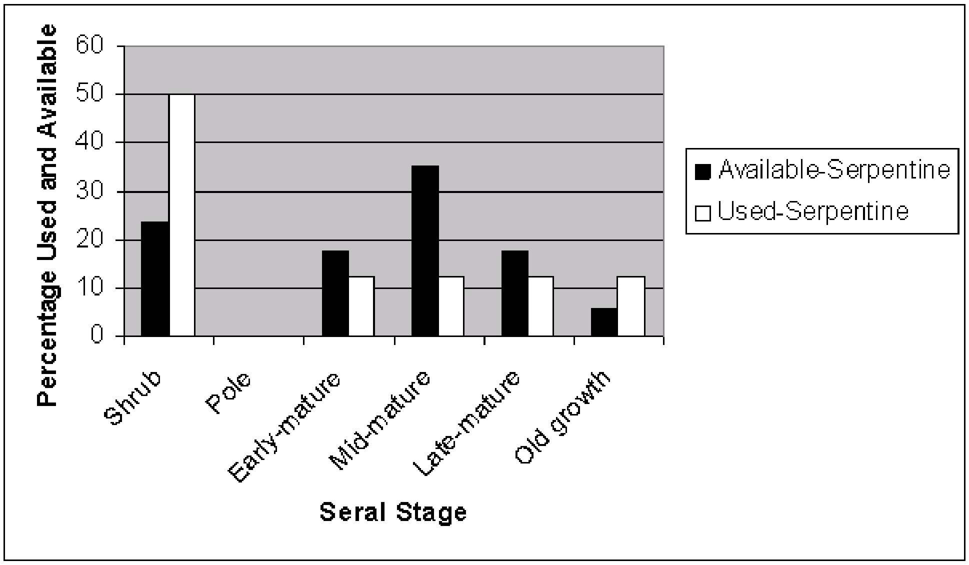
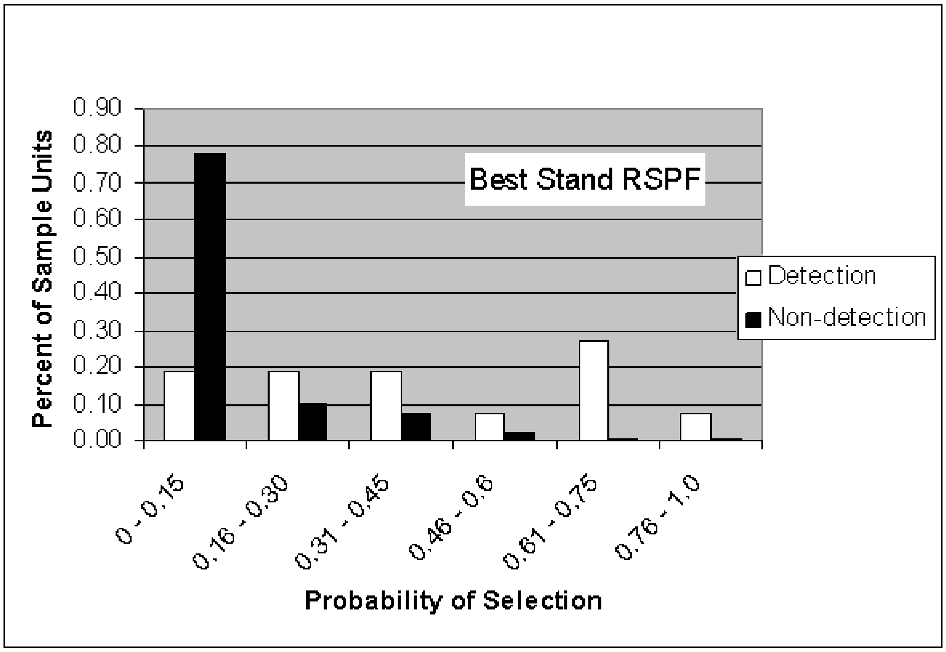


Figure 9. Classification success using the best stand scale model.



Home-Range Scale

At the home-range scale 8 models are included within the 95% confidence set, three (Models 1, 2, 3, Table 17) of which are highly competing for the best model based on ΔAIC_c values and relative weights. Each of these models is ≥1.84 times as likely as the next model (Model 4, Table 17). However, model pairs 2 and 3, and 5 and 6, appear almost identical suggesting that the OLM patch and OLM composition variables are highly correlated and that model redundancy is a concern for these models. Using the methods described by Burnham and Anderson (1998) to adjust for model redundancy, the corrected the w_i for the 95% confidence set of models are presented in Table 18.

Table 17. RSPFs at the home-range scale are presented, the dashed line indicates the end of the 95% confidence set. X's indicate that a variable is included within a model. K represents the number of parameters in a model.

	Variable										
RSPF #	Serpentine	OG Patch	OLM Patch	OLM Composition	Amount Logged	OG Composition	Stream	K	ΔAIC	*w*	Relative Weights
1	X	X						3	0.00	0.206	1.00
2	X		X					3	0.07	0.198	1.04
3	X			X				3	0.08	0.198	1.04
4	X	X			X			4	1.26	0.109	1.88
5	X		X		X			4	2.07	0.073	2.82
6	X			X	X			4	2.16	0.069	2.98
7	X					X		3	3.01	0.045	4.12
8	X	X			X		X	5	3.39	0.037	5.56
------	------	------	------	------	------	------	------	------	------	------	------
9	X				X	X		4	4.10	0.026	7.9
10	X		X		X		X	5	4.20	0.025	8.2
11		X			X			3	9.57	0.001	208.0
12		X						2	10.31	0.001	208.0
13					X			2	10.46	0.001	208.0
14					X	X		3	11.55	0.000	>208.0
15		X			X		X	4	11.65	0.000	>208.0
16			X		X			3	11.77	0.000	>208.0
17			X					2	12.00	0.000	>208.0
18				X	X			3	12.38	0.000	>208.0
19				X				2	12.42	0.000	>208.0
20				X				2	12.51	0.000	>208.0
Null								1	13.42	0.000	>208.0
21					X	X	X	4	13.62	0.000	>208.0
22			X		X		X	4	13.82	0.000	>208.0
23				X	X		X	4	14.38	0.000	>208.0
24				X			X	3	14.44	0.000	>208.0
25		X					X	3	14.56	0.000	>208.0

Table 18. w_i corrected for model redundancy for the 95% confidence set of home-range scale models.

RSPF #	Serpentine	OG Patch	OLM Patch	OLM Composition	Amount Logged	OG Composition	Stream	K	*w**	Relative Weights*
	Variable									
1	X	X						3	0.29	1.00
2	X		X					3	0.14	2.07
3	X			X				3	0.14	2.07
4	X	X			X			4	0.15	1.93
5	X		X		X			4	0.05	5.80
6	X			X	X			4	0.04	7.25
7	X					X		3	0.06	4.83
8	X	X			X		X	5	0.05	5.80

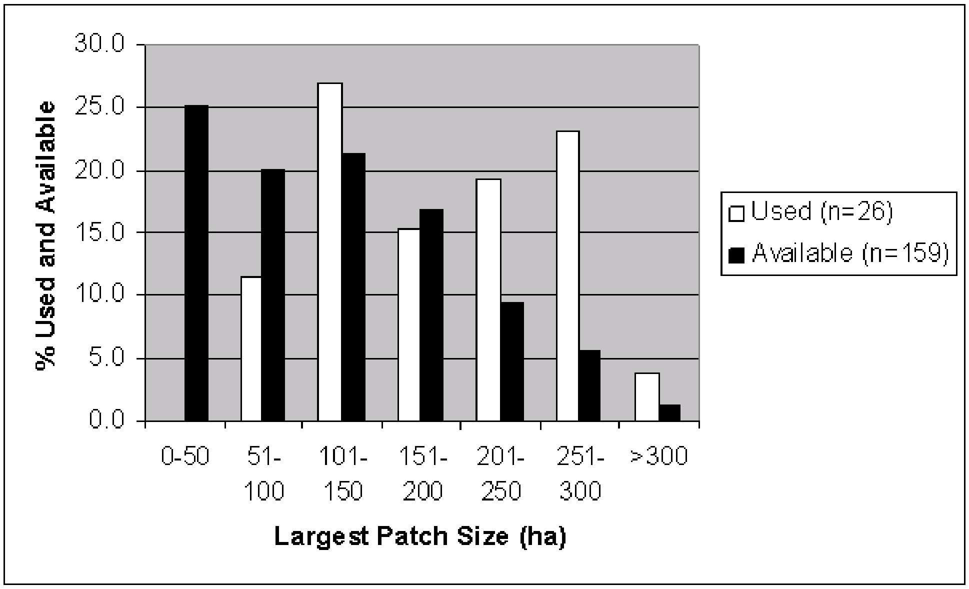
*corrected for model redundancy.

The serpentine variable had the highest importance weight and was positively associated with marten occurrence (Table 19). Specifically, a 20 ha increase in serpentine area was associated with an 18% increase in the probability of marten occurrence (odds ratio = 1.18, 95% CI = 1.07 to 1.29). The top four models had one of three late-successional forest associated variables, which were all positively associated with the probability of marten occurrence. In model 1, a 20 ha increase in the old growth patch size was associated with a 26% increase in marten occurrence (odds ratio = 1.26, 95% CI = 1.05 to 1.51), after accounting for the amount of serpentine habitat. In model 2, a 20 ha increase in the old growth and late mature patch size was associated with a 19% increase in marten occurrence (odds ratio = 1.19, 95% CI = 1.03 to 1.37), after accounting for the amount of serpentine habitat. In model 3, a 20 ha increase in the total composition of old growth or late-mature forest was associated with a 21% increase in marten occurrence (odds ratio = 1.21, 95% CI = 1.03 to 1.41; Table 20), after accounting for the amount of serpentine habitat. The top three models suggest that the largest patch size of either old growth, old growth plus late mature, or serpentine habitat within a 1-km radius of each sample unit is important for martens. Martens disproportionately used sample units within these largest patch sizes (Figure 10). The mean maximum patch size within a 1-km radius of sample units where martens were detected and were not detected was 181 Ha (SD = 73) and 101 Ha (SD = 75), respectively. The smallest maximum patch sizes of either old growth, old growth plus late-mature, or serpentine habitat for sample units used by martens was 83.4, 89.4, and 88.9 Ha, respectively. Many of the patches in this

Table 19. Normalized importance weights for all home-range scale variables based on w_i corrected for model redundancy.

Serpentine	0.328
OG Patch	0.291
OLM Composition	0.128
OLM Patch	0.113
Amount Logged	0.069
OG Composition	0.053
Stream	0.035

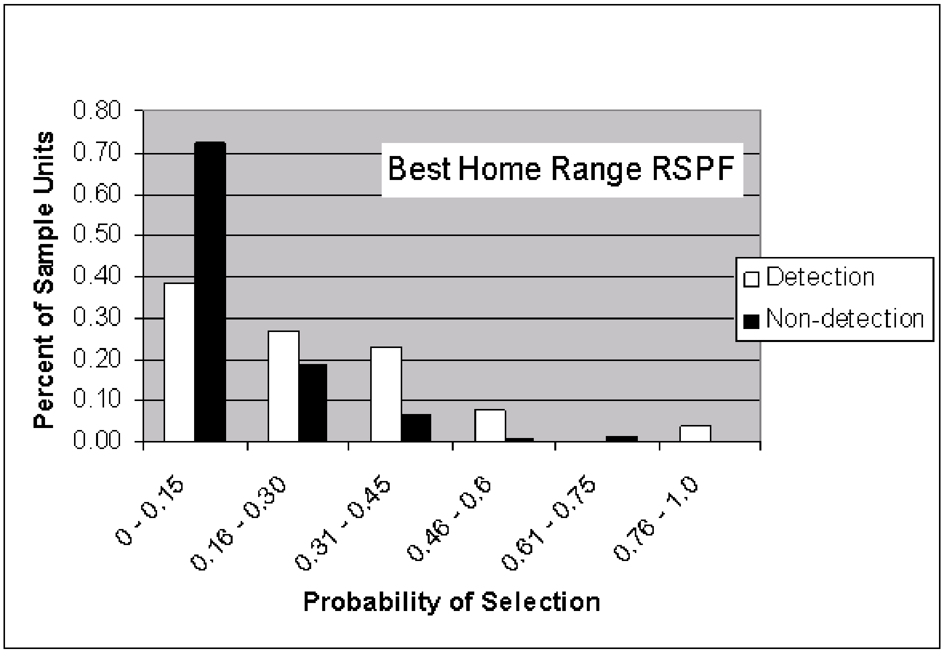
Figure 10. Percent used and available for size classes of the maximum contiguous old growth, old growth plus late mature, or serpentine patch within a 1-km radius for each sample unit.



analysis were actually larger, but sizes were truncated by perimeter of the 1-km radius circle used to characterize the home-range area.

Classification success using the best home range model (Model 1, Table 17) is presented in Figure 11.

Figure 11. Classification success for the best home range scale model.



Mixed Scale

Although the 95% confidence set of models at the mixed scale contained 4 models, the model with the lowest ΔAIC_c value (Model 1, Table 20) was 44.5 times more likely than the next model (Model 2) and had a *w* of 0.89. Model 1 contained two stand variables describing the seral stage (SERAL) and amount of shrub cover (SHRUB_C) and one home-range scale variable relating to the amount of area within a 1-km radius that had been logged (LOGGED). The seral stage variable had the most importance (Table 21) and represented the same pattern shown in Figures 7 and 8. Specifically, relative to the old-growth seral stage, the shrub stage was associated with a 35% increase (odds ratio = 1.35, 95% CI = 0.24 to 7.61), the pole stage a 73%

decrease (odds ratio = 0.27, 95% CI = 0.03 to 1.96), the early-mature stage a 90% decrease (odds ratio = 0.10, 95% CI = 0.01 to 0.99), the mid-mature stage a 95%

Table 20. RSPFs at the mixed scale are presented, the dashed line indicates the end of the 95% confidence set. X's indicate that a variable is included within a model. K represents the number of parameters in a model.

	Variable											
RSPF #	Shrub Cover	Seral Stage	Tree Cover	Amount Logged	OLM Patch	OLM Composition	OG Patch	OG Composition	K	ΔAIC	*w*	Relative Weights
1	X	X		X					8	0.00	0.890	1.0
2	X				X				3	7.30	0.023	44.5
3	X					X			3	8.32	0.013	89.0
4	X			X	X				4	8.51	0.012	89.0
------	------	------	------	------	------	------	------	------	------	------	------	------
5	X		X						3	9.14	0.009	98.8
6	X		X		X				4	9.20	0.008	111.2
7	X						X		3	9.58	0.007	127.1
8	X			X		X			4	9.77	0.006	148.3
9	X			X			X		4	9.77	0.006	148.3
10	X		X			X			4	10.18	0.005	180.0
11	X							X	3	10.86	0.003	296.6
12	X			X				X	4	10.91	0.003	296.6
13	X		X				X		4	11.20	0.003	296.6
14		X		X					3	11.39	0.002	445.0
15	X		X					X	4	12.20	0.001	890.0
Null									1	30.89	0.000	>890.0

*The following X variables were not included in this set of models: %Conifer, macro-aspect/slope position, Stream, Serpentine.

decrease (odds ratio = 0.05, 95% CI = 0.01 to 0.30), and the late-mature stage a 75% decrease (odds ratio = 0.25, 95% CI = 0.06 to 0.99) in marten occurrence after accounting for shrub cover and amount logged (Table 22). The variable for amount of area logged within 1-km had the second-most importance (Table 21). A 10% increase in the amount of area logged was associated with a 23% decrease in the odds of

Table 21. Normalized importance weights for all mixed scale variables.

Seral Stage	0.837
Amount Logged	0.249
Shrub Cover	0.133
OLM Patch	0.027
OLM Composition	0.016
OG Patch	0.010
Tree Canopy Cover	0.009
OG Composition	0.006

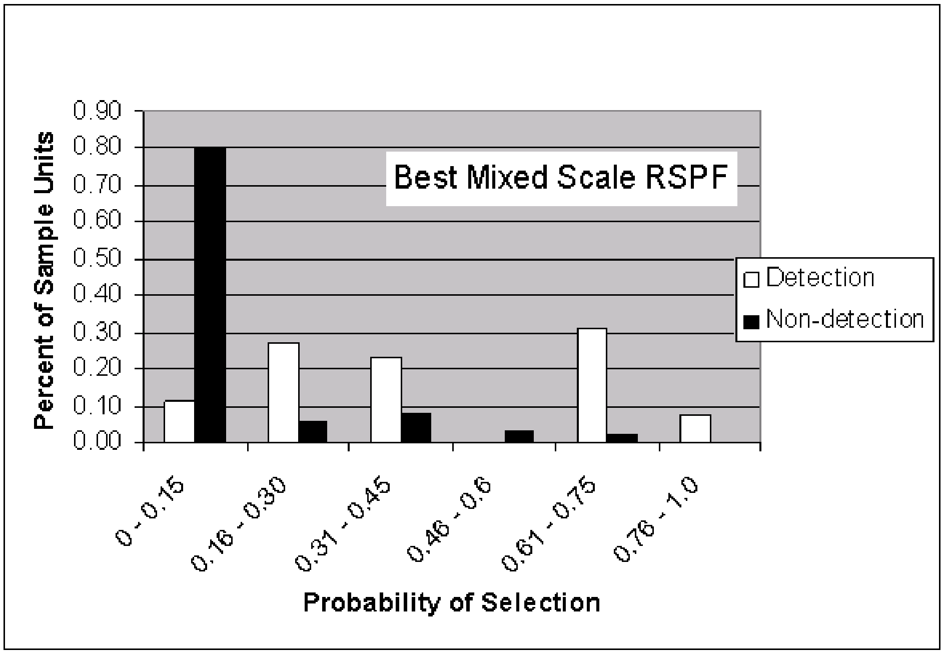
Table 22. Variable coefficients and odds ratios for the best mixed scale RSPF.

Variable	Estimate	95% CL	odds ratio
Shrub Cover	0.038	0.017 to 0.063	1.47
% Logged	-2.560	-5.789 to 0.010	0.77
Intercept	-1.997	-4.350 to 0.141	
Seral Stage			
Shrub	0.30	-1.445 to 2.073	1.35
Pole	-1.30	-3.492 to 0.610	0.27
Early-mature	-2.72	-5.302 to -0.319	0.10
Mid-mature	-2.90	-4.915 to -1.353	0.05
Late-mature	-1.36	-2.779 to -0.043	0.25
Old Growth	Reference		

marten occurrence (odds ratio = 0.77, 95% CI = 0.58 to 1.03; Table 22), after accounting for seral stage and shrub cover. Shrub cover had the third highest importance weight (Table 21) and a 10% increase in shrub cover was associated with a 47% increase in the odds of marten occurrence (odds ratio = 1.47, 95% CI = 1.16 to 1.85), after accounting for seral stage and amount of area logged.

Classification success using the best mixed scale model (Model 1, Table 19) is presented in Figure 12.

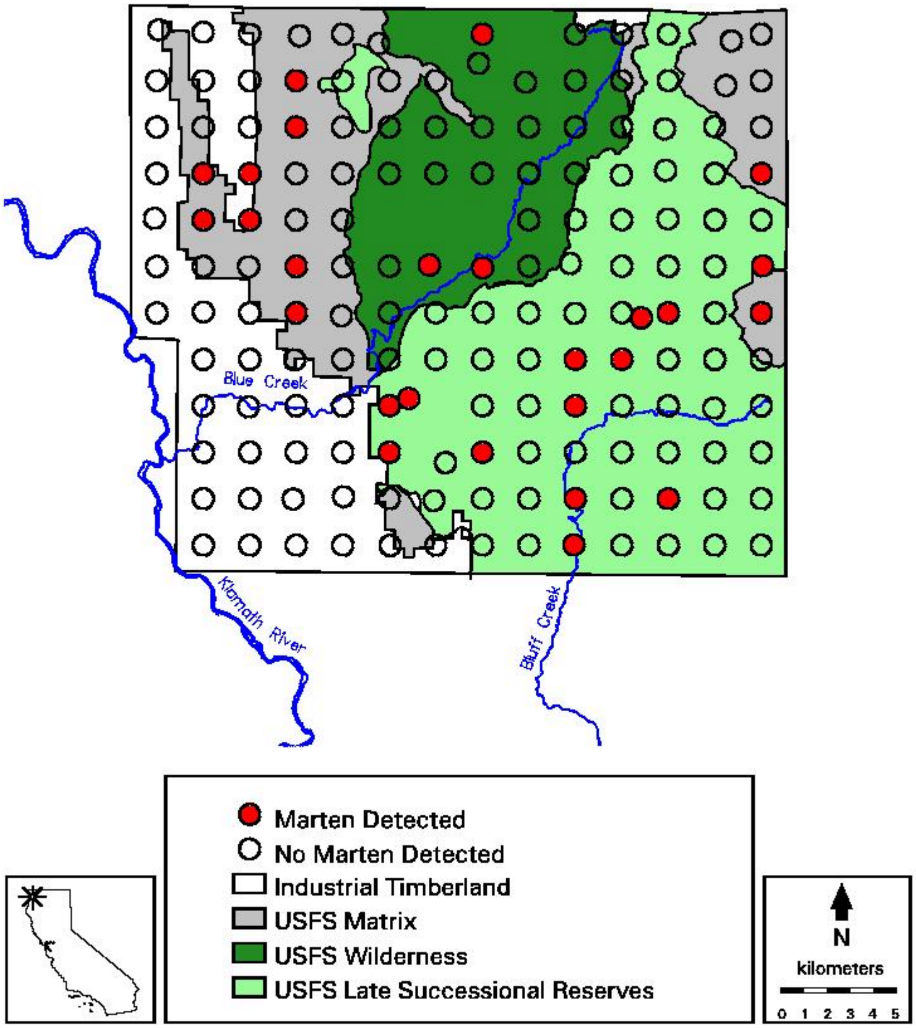
Figure 12. Classification success for the best mixed scale model.



Management Unit Comparison

Martens were detected at 2 of 36 (5.5%) sample units located on the Private Industrial Timberlands (PIT) and 24 of 123 (19.5%) sample units located on U. S. Forest Service lands. Of the sample units on U. S. Forest Service lands, martens were detected at 8 of 31 sample units (25.8%) in matrix lands (FSM), 13 of 66 (19.6%) in late-successional reserves (LSR), and 3 of 23 (13.0%) in wilderness (Figure 13). The

Figure 13. Marten detection results and management units.



proportion of sample units where martens were detected on PIT was significantly less than that on USFS lands ($\chi^2 = 3.95$, df = 1, p = 0.049). On USFS lands, the proportion of sample units where martens were detected was nearly significantly less on FSM versus USFS reserves (LSR and wilderness; $\chi^2 = 2.98$, df = 1, p = 0.088).

DISCUSSION

Multi-scale Habitat Characteristics

Martens used two structurally distinct forest habitat types, those with serpentine soil types and those on more productive soil types. Serpentine habitats used by martens have open tree canopies, dense shrub cover, an abundance of boulder piles and are in various seral stages, while non-serpentine habitats have closed, multi-layered tree canopies, dense shrub cover and are in the oldest seral stages. The locations where martens were detected in serpentine habitats occurred on a single ridge complex (Rattlesnake-Red Mountain complex) on the western side of the study area and were within close proximity (13 - 20 km) of the ocean (Figure 5). These locations, combined with several detection locations on the western Siskiyou National Forest in southwestern Oregon, comprise the only areas of serpentine habitats known to be occupied by martens (Zielinski et al. 2001, Slauson and Zielinski 2002) and appear to be restricted to the most mesic and near-coast vegetation series, the western white pine series, of those found in serpentine habitats (Jimerson et al. 1995). Non-serpentine forest types where martens were detected in my study area are typical of the dominant forest types found in coastal Northwestern California as well as southwestern Oregon (Franklin and Dyrness 1988, Barbour and Majors 1988). In general non-serpentine forest types used by martens were similar to typical marten habitat described in other geographical areas (e.g., Buskirk and Powell 1994, Buskirk and Ruggiero 1994), while serpentine forest types were not.

Microhabitat Characteristics

Martens detected in serpentine habitat sites were at higher elevations and occupied mid- and upper-slope positions with no clear trend in macro-aspect, reflecting the ridge-top distribution of serpentine habitats within the study area whereas in non-serpentine communities martens were generally detected in mid and lower slope positions and often in the most mesic macro-aspects. Mesic aspects generally provide a more productive environment for plants to grow. Vegetation structure on mesic aspect sites tends to be conifer-dominated and, at mid- and lower elevations, support dense shrub layers composed of mesic site species (e.g., salal, evergreen huckleberry; Jimerson et al. 1996). Mesic aspects may also provide more moderate thermal environments, which become especially important for martens during the summer when mean temperatures can exceed 32° C (Jimerson et al. 1996).

The forest structure at non-serpentine sites where martens were detected consisted of dense, multi-layered tree canopies. Overhead cover, especially in the form of dense tree cover is known to be important for martens and they will often avoid entering areas without it (e.g. Drew 1995). Overhead cover provides both protection from avian predators and escape routes (e.g. vertical boles) from terrestrial predators (Bissonette et al. 1997). The vegetative structure at non-serpentine sites where martens were detected supports both of these features as well as a well-developed understory often dominated by mast-producing hardwoods (e.g. tanoak and chinquapin) and a dense shrub layer. Serpentine sites with detections sometimes lacked trees altogether, suggesting that dense shrub layers may provide the necessary element of overhead cover for martens to enter them. Furthermore, serpentine sites where martens were detected had large amounts of boulder-sized surface rocks, a structural feature not present at non-serpentine sites. These surface rocks create interstitial spaces that may be used for escape cover where tree boles are sparse or absent. In addition, the abundance of rocks provides suitable resting locations for martens (Slauson and Zielinski in prep.(a)) and habitat for prey species such as chipmunks and golden-mantled ground squirrels (pers. obs.). Although hardwood trees are typically absent from serpentine sites, acorn-producing shrub species (e.g., dwarf tanbark, huckleberry oak) often dominated the shrub layers in these sites.

Conifer and hardwood snags had a higher basal area and larger mean diameters at non-serpentine sites where martens were detected than at non-serpentine sites where martens were not detected. Large diameter snags are known to be important for use as resting structures (Raphael and Jones 1997, Ruggiero et al. 1998) and as habitat for prey species. Availability of suitable resting structures in close proximity to foraging locations likely increases the suitability of a site by reducing the energetic costs associated traveling between different areas to meet both needs (Marshall 1946, Simon 1981). Conversely, martens were detected at serpentine sites with a lower mean diameter of snags than at serpentine sites where they were not detected, further suggesting that the presence of large woody structures may not be as important for martens in serpentine habitats.

Stand Scale Habitat Selection

At the stand scale martens selected conifer-dominated stands with dense shrub cover in the oldest seral stages in non-serpentine areas and in various seral stages in serpentine areas. The non-serpentine results are consistent with the paradigm that martens are specialists for late-successional stands of mesic coniferous forest in the western United States, especially those with complex physical structure near the ground (Buskirk and Powell 1994). Stands with these characteristics typically provide the key structural elements and prey populations required by martens. Late-mature and old-growth seral stages in the tanoak and Douglas-fir vegetation series in northwestern California have the highest mean densities of large diameter (mean >80 cm), tall (mean > 30m) snags relative to all other seral stages (Jimerson et al. 1996). In Douglas-fir associated forest stands in the coast ranges of the Pacific states, large downed logs are most abundant in the old-growth seral stage (Franklin et al. 1981, Spies et al. 1988). Thus, the non-serpentine stands selected by martens likely provide for key life history needs, which include providing overhead and escape cover, suitable resting and denning structures, and supporting important prey populations. In non-serpentine areas, all earlier seral stages were selected against, likely due to the lack of one or more key structural elements. Of the 3 earlier-seral non-serpentine stands used by martens, 2 were pole stage stands with dense shrub cover adjacent to old growth stands and 1 was a mid-mature stand with large conifer predominants present in the stand. My results for selection for the oldest seral stages and selection against younger stages in non-serpentine habitats are differ from those of Baker

(1992), who found that martens in coastal forests of Vancouver Island selected for second growth (10-40 years) and used mature (40-120 years) and old growth (>120 years) proportionally less than available. However, Baker's second-growth stands were unique in that they were highly structurally complex due to the presence of large amounts of residual large wood left after logging, which provided suitable resting and denning locations and abundant shrub and herb cover. Furthermore, comparisons of habitat use in my study to those of Baker (1992) on Vancouver Island are complicated due to the limited spatial extent of Baker's study area (65 km^2), small and highly patchy amount of her study area composed of mature and old-growth forest (24%), and to the depauperate small mammal fauna (e.g., lacking *Clethrionomys* sp.) resulting in a habitat generalist (deer mouse, *Peromyscus maniculatus*) being a dominant prey species.

The use of nearly treeless stages and lack of selection for any other seral stage in serpentine habitats further suggests that an alternative structural element is likely providing for the life history needs (e.g., resting structures) that large live and dead woody structures typically provide. I hypothesize that the combination of interstitial spaces created by abundant surface rocks and dense shrub cover allows martens to use stands in highly developed shrub communities on serpentine sites. These cover features may provide some of the life history needs provided elsewhere by cavities and platforms in large diameter trees, snags, and logs.

Shrub cover has been reported to be used by martens as resting locations (Martin 1987), foraging locations (Buskirk and McDonald 1984), and as important overhead cover following disturbances from fire (Magoun and Vernam 1986, Paragi et al. 1996), spruce budworm defoliation (Chapin et al. 1997), and partial harvesting (Fuller and Harrison 2000). Dense shrub cover was a consistent feature for both serpentine and non-serpentine stands selected by martens and represents a distinct layer that continues throughout entire stands and often continues unbroken into adjacent stands. Shrub layers were typically dominated by mast-producing ericaceous and oak species and not by early-seral *Ceanothus* species (e.g., *C. veluntinus*, *C. thyrsiflorus*). Dense, extensive shrub cover is an endemic structural feature in the coastal forests of northwestern California (Jimerson et al. 1995, Jimerson et al. 1996, Mahony 1999, Sawyer et al. 2000). In mesic near-coast non-serpentine forest types, development, persistence, and productivity of shrubs are closely related to the amount of competition from the tree canopy for light (Tappeiner et al. 2001). As a consequence, shrubs are most developed in either early or late seral stages. In the most common serpentine vegetation series in which martens are found, the western white pine series, the shrub layer is the most dominant structural layer (Appendix G; Jimerson et al. 1995).

Dense shrub layers provide direct overhead cover from avian predators and a highly complex environment for terrestrial pursuit by other mammalian predators. Of the 26 sample units where martens were detected, potential predators and competitors of martens were detected at only at 4 sample units (fisher 1, gray fox 3) despite their abundance elsewhere in the study area (fisher 11, gray fox 5) and in nearby forest types with sparse shrub layers (Carroll et al. 1999, Klug 1997, Zielinski et al. 2000, Slauson and Zielinski 2003). Fishers and gray foxes were only detected at 12 (7.5%) and 8 (5.0%) of the 159 sample units within my study area, respectively. Systematic track plate surveys conducted throughout areas adjacent to the study area detected fishers at 54.2% and gray foxes 54.2% of sample units (n = 35) on USFS lands (Zielinski et al. 2000), fishers at 65.0% of sample units (n = 40) on Simpson timberlands (Klug 1997), and fishers at 30.4% and gray foxes at 30.4% of sample units (n = 23) on Redwood National and State Park lands (Slauson and Zielinski 2003). Krohn et al. (1995) hypothesized that high fisher populations can limit marten populations and that dense snowfall can limit fisher populations. Most of my study area and the locations where martens were detected remain snow-free or receive limited, often ephemeral snowfall. Weir and Harestad (2003) found that fishers in Douglas-fir forests of British Columbia selected against stands with dense (>80%) low shrub cover and hypothesized that overly complex structure near the ground may reduce the likelihood of capturing prey. The presence of a dense shrub layer as a landscape feature may help explain why martens in the study area occupy highly productive coastal forests that receive little or no snowfall, while fairly common larger-bodied terrestrial predators and competitors apparently do not. The results from recent surveys conducted in Redwood National and State Parks further support this hypothesis as both fishers and gray foxes were detected most commonly in second growth stands with sparse or moderate shrub cover and were rarely detected in old growth stands with dense shrub cover (Slauson and Zielinski 2003).

Shrubs also provide food for martens directly, through production of berries, and indirectly, by supporting prey populations that consume berries, seeds, and vegetative parts of these shrubs. Berries have been found in marten scats from June until late November and were present in over 80% of >200 marten scats collected in the study area (unpubl. data). Although snowfall in my study area can be highly ephemeral, the shrub layers may also provide subnivien access in high elevation stands where snowfall may persist.

Home-range Scale Habitat Selection

Using the best mixed-scale model, the probability of martens selecting a 1-km radius area was inversely related to the amount of area logged at the home-range scale. Sixty percent of the sample units where martens were detected had ≤13% of the 1-km radius logged and no marten was detected at a sample unit with >50% of the total area within a 1-km radius logged. The dominant method of logging within the study area has been clear-cut logging. Logging causes both loss and fragmentation of habitat for martens. Within U.S. Forest Service lands in the study area logging has mostly removed old-growth stands in the tanoak vegetation series (Jimerson et al. 1996) and >80% of all stands have been logged on Simpson Timber Company lands. The negative effect of logging on martens is consistent with results from several studies conducted at different spatial scales in different ecoregions across the marten's distribution (e.g., Campbell 1979, temperate coniferous forest, Wyoming; Snyder and Bissonette 1987, boreal taiga forest, Newfoundland; Thompson and Colgan 1994, boreal taiga forest Ontario; Chapin et al. 1998, temperate broadleaf mixed forest, Maine; Hargis et al. 1999, temperate coniferous forest, Utah). Studies conducted at the stand scale have found that martens make little use of recent clearcuts and may not use them for several decades until suitable conditions develop (for review, see Buskirk and Ruggiero 1994). In areas with clear-cut logging in Maine, martens occupy home ranges that maximize the area of mature residual forest and minimize the area of recent clearcuts (Katnik 1992). Studies conducted in Maine, Utah, and Quebec suggest that martens avoid landscapes with more than 25-30% of mature forest removed from logging (Bissonette et al. 1997, Potvin et al. 2000).

Using the best home-range scale models developed here, the probability that a marten will be detected increases: (1) as the size of the largest contiguous patch of old growth or old growth plus late-mature increases, (2) as the total amount of old growth and late-mature increases, and (3) as the total area of serpentine habitat increases. Mean differences for univariate results for both the largest contiguous old growth patch and amount of serpentine habitat are among the largest for all home-range variables (Appendix F). Apparent selection for larger contiguous patch sizes of suitable habitat at the home- range scale is consistent with the results of other studies. For example, Chapin et al. (1998) found that martens in an industrial forest landscape in Maine incorporated the largest residual forest patches into their home ranges and that larger patches were used significantly more than small patches. In this study, martens showed greater proportional use of sample units with large patch sizes (Figure 10). These results suggest that martens visited sample units within larger maximum patch sizes composed either of old growth, old growth plus late-mature, or serpentine habitat. Chapin et al. (1998) found that the largest residual patch composed a median of 75% (range 30-90%) of the home ranges of 13 male martens and a median of 80% (range 51-93%) of 14 female martens. I found similar results in my study where the largest maximum patch comprised a median of 50% (range 26-100%) of the 1-km radius circles around sample units where martens were detected. Further research will be necessary to confirm the relationships of these patches to the composition of marten home ranges of martens in coastal Northwestern California.

Management Units

Martens were detected proportionally more frequently on lands managed by the USFS than on private industrial timberlands. Martens were only detected at 2 sample units on private industrial timberlands, both of which were within 200 m of USFS lands and adjacent to or within unlogged serpentine stands located on both PIT and USFS lands. Studies conducted in Maine, Utah, and Quebec found that martens appear to avoid landscapes with more than 25-30% of mature forest removed (Bissonette et al. 1997, Potvin et al. 2000). Within the PIT portion of the study area, >80% of all stands have been logged and martens appear to avoid all but the edge of this landscape. Although PIT lands within the study area contained a large proportion of redwood associated forest types, this probably is not a factor explaining the rarity of marten detections as the majority of the historical range of the Humboldt marten and most verifiable historical records for the subspecies occur in redwood-associated forest types (Grinnell et al. 1937). Phillips (1994) reported that martens occupied <33% of an industrial forest landscape and >80% of an adjacent forest preserve in

Maine. In my study area martens occupied 5.8% of the sample units in industrial forest landscape and 19.5% of the sample units in a landscape composed of reserves and lightly logged (<15%) areas.

Martens were likely detected proportionately more frequently in Forest Service matrix lands than in Forest Service reserves due to the disproportionate availability of serpentine habitats and old growth stands in these two management units (Figure 2). USFS matrix lands and LSRs within the study area contain >80% of all the available old growth and >75% of all available serpentine habitat. The portion of the Siskiyou Wilderness within the study area was composed mostly of higher elevation vegetation series, such as white fir, and hardwood dominated stands, which were not used by martens in this study. The absence of martens from white fir forest types in this study is interesting because martens are widely distributed in white fir- associated forests in their distributions in the southern Cascade and Sierra Nevada mountains of California (Zielinski et al . 2000). White fir forest types were only found in the higher elevations of the northeastern portion of the study area and in these areas they contained very little shrub cover. Further study will be necessary to determine whether martens do not make use of white fir forest types in the Klamath mountains of northwestern California.

Conservation and Management Implications

A significant number of marten detections (38%) occurred on lands (PIT and USFS matrix lands) that are available for logging currently and lack strategies to maintain suitable marten habitat and are currently. Both martens and their habitat are patchily distributed in the area, and further loss or degradation of limited suitable habitat could decrease the chances for the persistence of this remnant population. Results at the stand and home-range scales provide important information that can be applied within and outside the study area to evaluate habitat suitability and to identify areas to survey for martens in order to avoid further negative impacts to this population.

A conservation strategy based solely on measures to maintain current conditions for this population is unlikely to ensure its long-term persistence. The two major challenges for persistence and restoration of the coastal California marten population are: 1) the longer a population remains small, the greater the chance that it will lose its genetic variation (Nei et al. 1975) or that it will be eliminated due to stochastic demographic or environmental events (e.g., wildfire; Fager 1991), and 2) restoration of forest habitats with the structural characteristics necessary to be suitable for martens may take many decades. Results from my study provide useful information that can inform conservation planning and site specific-restoration efforts. First, these characteristics can be used collectively to identify suitable habitat patches or areas of connectivity outside the study area in non-serpentine and serpentine habitats. In non-serpentine habitats, conifer-dominated late-successional stands with dense shrub cover in patches of 180 ha should be a minimum criterion to identify potential home range areas. The largest suitable, but unoccupied habitat patches should be evaluated for the potential for dispersing individuals to reach them. Second, where restoration efforts are needed to increase suitable habitat or restore habitat connectivity to facilitate dispersal and recolonization, the stand-scale structural elements identified (dense shrub cover, large trees, snags, and logs) should be used to develop site specific prescriptions. Specifically, early-seral stands in non-serpentine habitats could be managed with lower tree densities to encourage maintenance or regeneration of a productive shrub layer and to increase growth rates for the individual trees. For example Veirs (1986) summarized the results of a thinning experiment conducted in Redwood National Park where young (~30 year old) stands were thinned at spacings of 3 to 3.6 m and 4.8 to 5.4 m. Within 10-15 years a dense shrub understory resembling that of adjacent old growth stands had returned to the site. Opportunities for restoration efforts such as these currently exist both within the study area and on adjacent lands administered by the U.S. Forest Service, National Park Service, and California State Parks and those owned and managed by the Simpson Timber Company.

Although some habitat characteristics were similar between serpentine and non-serpentine areas used by martens, such as dense shrub cover and conifer dominance, non-serpentine areas should not be managed to create tree canopy structure (sparse canopy, low basal area of conifer) similar to serpentine sites. It is likely the combination of dense shrub layers and the presence of the large rocky features in the serpentine communities used by martens that provide the types of cover necessary to meet key life history needs (e.g., resting locations). While thinning early-seral stands in non-serpentine areas may produce similar tree densities as some serpentine sites, the goals of these management actions are to: 1. restore or maintain dense and productive shrub layers in the short term and 2. accelerate the growth of remaining trees to hasten the development of large live trees, a multi-layered canopy, and to recruit large snags and logs over the long-term.

Dense shrub cover is important to martens and likely many other species of wildlife that inhabit coastal forests and benefit from their use as food and or cover. While there are compelling ecological reasons to maintain and restore this important structural element, it does play a role in fuel loading and fire dynamics in coastal forests. Due to strong political and social forces becoming increasingly focused on reducing the potential for large scale fires, especially in the vicinity of communities, it is important to consider both the ecological importance of the shrub layer, the long fire-return interval in coastal forest ecosystems, and the lower chances for natural fire ignition due to the maritime influence (Agee 1993).

Scope of Inference

The results of this study are applicable to the coastal forests of northwestern California and southwestern Oregon. Within the study area, my sampling design provided an unbiased sample of microhabitat, stand, and home-range scale characteristics. An advantage of using resource selection probability functions to investigate selection at the stand and home-range scales is that the RSPFs are scaled such that the probability of use of a resource unit is calculated (Boyce and McDonald 1999). Thus these RSPFs can be applied to areas outside the study area for vegetation series that were adequately represented within the sample (Tanoak, Douglas-fir, Western white pine; Appendix G) to predict marten occurrence at the stand or home-range scale. Martens are typically more strongly associated with structural characteristics of forests than with vegetation types or vegetation composition (Buskirk and Powell 1994). Furthermore, martens in coastal northwestern California should be expected to use any mesic forest type within the historical distribution that provides the important structural elements described in this study and potentially those types with novel structural elements that provide the necessary life requirements.

The results of this study apply directly to habitat use during the summer to late autumn period (June to November). In several studies it has been demonstrated that martens show patterns of habitat use that differ with season, with increasing use of late-successional forest stands during the winter (for review see Buskirk and Ruggiero 1994). Thus the results for serpentine habitats should be considered applicable only to the seasons of the study until we better understand the use of these habitats by martens during the winter. In non-serpentine habitats, martens selected stands in the latest successional stages during the summer and fall and continued use of these stands during the winter and spring would be consistent with other studies of habitat use by martens during these seasons.

I have assumed that track plate stations are visited by actively foraging animals, however I do not know the similarity between these sites where martens are detected and the sites where they search for and kill prey. The attraction distance from the use of the small amounts of bait and olfactory lure is also unknown. Baited track plate stations do, however, help us understand the habitat characteristics of the micro-habitats martens are willing to visit. They can help us answer the question “of the collection of sample units where small baits are placed, what are the micro-habitat characteristics at locations that are visited compared to those that are not visited or, perhaps are avoided?" The use of baited track plate stations is one of the only ways to determine the exact locations of active martens. Direct observation is difficult, unpredictable, and unlikely if martens are foraging underneath dense shrub layers. Snow-tracking is the least biased method for gathering information on active animals (e.g. Powell 1994), but this information is seasonal and is unavailable for much of the study area. Many of the sample units where martens were detected occurred at elevations that remain largely snow-free during winter. Remote telemetry is unreliable due to the uncertainty of the animal's true location in relation to specific habitat characteristics.

Research Needs

Although there are several obvious benefits of the shrub structural layer for overhead cover and for providing seasonal fruits for martens, its relationship to prey populations, relationship to the distributions of other mesocarnivores, and its developmental dynamics are poorly understood. Specifically, further understanding of how the presence of the shrub layer affects the abundance and species composition of prey populations is needed. In this study few other mammalian competitors or predators, such as the fisher and gray fox, were detected in stands with dense shrub layers that martens selected. This pattern has also been observed in other regions (Zielinski et al. 2000, Slauson and Zielinski 2002, Slauson and Zielinski in prep.). Understanding the relationships of shrub density to potential competitors and predators of martens has important implications for regional conservation and restoration efforts and will increase our understanding of other mesocarnivore-habitat relationships in coastal forests. Further research is necessary to better understand the important factors (e.g canopy cover, aspect-slope position) for shrub layer development, persistence, and productivity to aid in both directing how and where stand restoration efforts should occur.

While martens were not detected in any of the logged stands composed of redwood associated forest types, further research will be necessary to develop a better understanding of the habitat associations of martens in un-logged or redwood forest types. This will benefit both the understanding of elements that may be lacking in logged redwood stands and provide additional guidance to their restoration for martens.

The serpentine habitats used by martens in this study are distinctly different than non-serpentine habitats. A better understanding of the available prey species and their habitat-relationships in these habitats will increase the understanding of how they relate to more typical habitats used by martens in the region. Furthermore, development of a better understanding of how or why martens use these unusual serpentine habitats may provide insight into causal mechanisms underlying habitat selection for this species.

Further research will be necessary to evaluate how well the relationships of the home-range scale results in this study relate to actual home range habitat compositions for martens in the study population. A radio-telemetry based study to determine home range habitat composition began in 2002 to address this issue (Slauson and Zielinski in prep(b)).

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APPENDICES

APPENDIX A. ANIMAL HANDLING PROTOCOL.

Trap Modifications

Each Tomahawk live trap has been modified to decrease the potential for injury and stress to the animals. A piece of masonite has been fitted onto the bottom of each trap to discourage digging and the potential for toe and claw damage. A wooden ‘cubby box’ will be attached to the back of each live trap. This will provide trapped animals with a dark enclosed area to seek refuge in. This may decrease the stress the animal endures while in the trap before it is checked, especially if other species discover the trap before the observers do. The cubby boxes also provide a convenient way to begin the handling procedure or release non-target species.

Trap Monitoring

Traps were checked twice daily, once in the early morning and once in the late afternoon. This was not be practical in extremely remote locations, however every effort was taken to adhere to this checking schedule. Bait (chicken) will be replaced daily or as needed. Gusto will be placed near each trap on the first day of the trapping duration and reapplied on the eighth day. Once near the trap location observers will approach the site slowly and as quietly as possible. If the trap is closed and an animal is present, the actions detailed below will ensue.

American Martens

Once a marten has been confirmed to be in the trap, a burlap cover is placed over the wire portion of the trap to calm and quiet the animal. If the animal is already in the cubby box then the sliding door on the front of the cubby is shut, isolating the animal in the box. If the animal has not entered the cubby after a few minutes with the burlap over the trap then the animal will be unagressively coaxed into the box and the sliding door shut. A suitable site is then chosen as the processing location. The mat and equipment to use are laid out in a systematic configuration. At this time the appropriate concentration (see Animal Use Form for concentrations and dosage) and maximum dosage of the Ketamine-Diazepam mixture is drawn into the syringe. The loaded syringe is then placed in a protective cylinder and placed on the capture mat. At this time the capture team moves the entire trap to the edge of the processing area. A canvas bag attached to a cylindrical steel-handling cone is secured onto the end of the cubby box. The bag and handling cone are spread out such that the animal can see light through the cone once the door on the cubby box is opened. At this time the syringe is placed near the handling cone and a large stick (8-10 centimeters in diameter) is gathered to assist in directing the animal into the cone. Once in position, the rear sliding door of the cubby box is opened. Once the animal has left the cubby, the stick is used to block off the trap end of the canvas bag and the sliding door on the cubby is shut. The bag is then detached from the cubby and the stick is then gently rolled up in the canvas bag toward the cone to guide the animal into the cone if it hasn't gone in already. The bag and stick are complete rolled up so the animal is isolated in the handling cone. The size of the animal is then assessed and any excess volume of drug is expelled. The animal is then injected in one of the hind leg muscles. It should take approximately 60 to 90 seconds for the animal to go down. Once it is clear that the animal is down it is removed from the cone and placed on the processing mat. The animal's vital signs (rectal temperature, respiration, heart rate) are checked and recorded; these will be checked about every five minutes. Ointment is then placed over the eyes of the animal since the drug inhibits the blinking ability of the animal. The animal's head and teeth will be inspected. Photographs of the wear of the dentition will be taken and the animal will be placed into a general age class (juvenile, adult middle, adult old). Then a small cover will be placed over the animal's eyes for the duration of the processing to reduce visual stimuli. At this time a PIT tag (each PIT tag has a unique number which can be scanned with a hand held reader) will be inserted beneath the skin between the scapulae so recaptured individuals may be identified. Next the sex of the animal will be determined by inspection of external genitalia. Females will be examined for signs of reproductive activity (e.g. teats will be examined and measured, see Frost et al. 1999). Bacculum size will be measured in males as a secondary aging criterion. Genetic samples consisting of hair clumps with follicles will be extracted from the tail of each animal. Each sample will be placed in an individually labeled (labeled with the PIT tag number) tube with a silicone desiccant. The animal will then be placed in a bag and measured using a Pezola scale. Additional body measurements (e.g. total length, rostral measures) and detailed pad measurements (e.g. total length, total width, interior/exterior distance from each toe to the interdigital pad, length and width if the interdigital pad) will be made, the latter measurements will be made with calipers. A series of photographs of the gular and groin coloration as well as photos of unique features will then be taken. At this point a check will be done to make sure all the data has been collected. Then the animal will be placed back in the cubby box and give at least one hour to recover. The animal is checked on periodically during the recovery period in order to detect complications. If the animal appears coherent and responsive at that time it will be released. Before the door is opened on the cubby box, two track plate boxes (without screens) are placed together with two track plates (the first completely sooted and the second completely covered with contact paper) are placed in front of it. Thus when the animal leaves it will leave its tracks, which will be used to investigate intra-sexual track size differences as well as compared to the pad measurements of each individual.

Other species

Once a non-target species has been confirmed to be in the trap, a burlap cover will be placed over the trap and the animal will be left for several minutes to clam while the necessary equipment is gathered. The animal will then be compressed in the rear of the trap with a plunger (the end of the plunger will have a rigid square piece covered with padding) and given a unique mark (sharpie mark or small clip of fur taken in an obvious location on the animal) so that recaptured animals can be identified. Skunks will simply be released to reduce the chance of the traps being coated with their spray.

APPENDIX B. LIST AND DESCRIPTIONS FOR ALL SPATIAL DATA LAYERS USED IN THE ANALYSIS.

Data Layer	Source, Description, and Reference
Vegetation Layer	Source: Six Rivers National Forest Description: Polygon coverage created through areal photographic interpretation. Assignment of vegetation series and seral stage based on plot level data and ground truthing of polygons (see Jimerson et al. 1996 for more detail).
Streams	Source: United States Geological Survey (USGS) Description: This coverage was created for northwestern California from a USGS 1:100,000 digital line graph coverage for streams.
Serpentine Soils	Source: Six Rivers National Forest Description: Polygon coverage for ultramafic soils located on the Six Rivers National Forest and immediately adjacent private lands. Created from 1996 soils coverage for the forest that was digitized from soil maps for the region.

APPENDIX C. SELECTED DESCRIPTIVE VARIABLES, LOG AND SNAG DATA FOR SERAL STAGES IN THE TANOAK AND DOUGLAS-FIR VEGETATION SERIES. ALL INFORMATiON PRESENTED IS FROM JIMERSON ET AL. 1996. SNAG AND LOG CLASSES ARE DEFINED BY DIAMETER (CM) AND HEIGHT OR LENGTH (M) COMBINATIONS, IN PARENTHESIS. MEANS AND STANDARD DEVIATIONS, IN PARENTHESIS, ARE PRESENTED.

	SERAL STAGE					
Vegetation Series Variable	Shub	Pole	Early-mature	Mid-mautre	Late-mature	Old growth
Tanoak Series						
Snag Density (snags/hectare)						
(>50.8 cm & 15.2 m)	0	0	0.24 (0.1)	0.64 (0.2)	0.24 (0.0)	0.64 (0.0)
(>50.8 cm & 6 -15 m)	0	0	0.56 (0.2)	0.76 (0.3)	0.32 (0.1)	0.72 (0.0)
(>50.8 & >6 m)	0	0	0.80 (0.2)	1.33 (0.4)	0.48 (0.1)	1.37 (0.1)
Snag Diameter (cm)						
(>50.8 cm & 15.2 m)	0	0	76.7 (6.7)	71.1 (4.5)	110.9 (21.3)	92.9 (2.2)
((>50.8 cm & 6 -15 m)	0	0	102.8 (11.1)	57.6 (4.8)	87.1 (1.5)	81.0 (2.7)
(>50.8 & >6 m)	0	0	86.6 (6.6)	66.8 (3.8)	105.6 (16.7)	88.9 (1.7)

Vegetation Series Variable	SERAL STAGE Shub	Pole	Early-mature	Mid-mautre	Late-mature	Old growth
Douglas fir Series						
Snag Density (snags/hectare)						
(>50.8 cm & 15.2 m)	0	0	0.24 (0.1)	0.12 (0.0)	0.36 (0.2)	0.97 (0.1)
(>50.8 cm & 6 -15 m)	0	0	1.25 (0.6)	0.28 (0.2)	0.22 (0.1)	0.52 (0.1)
(>50.8 & >6 m)	0	0	1.49 (0.6)	0.40 (0.2)	0.60 (0.2)	1.45 (0.1)
Snag Diameter (cm)						
(>50.8 cm & 15.2 m)	0	0	82.5 (12.1)	61.4 (8.8)	84.5 (13.2)	86.6 (3.5)
(>50.8 cm & 6 -15 m)	0	0	106.6 (5.8)	92.7 (11.1)	86.8 (7.8)	92.7 (9.3)
(>50.8 & >6 m)	0	0	98.5 (6.0)	82.2 (9.3)	81.1 (11.4)	87.1 (3.3)

Vegetation Series Variable	SERAL STAGE Shub	Pole	Early-mature	Mid-mautre	Late-mature	Old growth
Tanoak Series						
Log Density (logs/hectare)						
(>76.2 cm)	2.26 (0.8)	3.27 (1.1)	2.14 (0.8)	0.72 (0.3)	0.08 (0.0)	1.74 (0.2)
(>50.8 to 76.2 cm)	3.60 (1.1)	4.41 (1.2)	2.18 (0.7)	1.94 (0.8)	0.72 (0.3)	2.63 (0.2)
Douglas fir Series						
Log Density (logs/hectare)						
(>76.2 cm)	3.28 (1.0)	1.98 (0.8)	4.86 (2.3)	0.85 (0.4)	0.28 (0.2)	1.54 (0.4)
(>50.8 to 76.2 cm)	7.20 (1.7)	2.99 (1.2)	4.57 (1.9)	1.66 (0.5)	2.55 (0.7)	2.79 (0.7)

APPENDIX D. CALIFORNIA WILDLIFE HABITAT RELATIONSHIPS CLASSIFICATION RESULTS FOR EACH STATION.

Eleven different CWHR habitat types were sampled, with marten detections occurring in only 6 of these (Table 1). The majority of marten detections (24) occurred in the Douglas-fir (9) and mixed hardwood-conifer (15) types. The highest proportion of detections (2 of 3) occurred in the montane chaparral type. All 6 tree size classes (1-6) and one shrub size class (3) were sampled, with marten detections occurring in 5 of the six tree size classes and in the single shrub size class (Table 1). Marten detections occurred most often in the larger tree size classes (3-6). All 4 tree and 1 shrub canopy closure class were sampled, with marten detections occurring in every class (Table 1). Marten detections in non-serpentine sites occurred almost exclusively (27 of 28) in the dense (≥60%) tree canopy closure class, while detections in serpentine sites occurred in all tree canopy closure classes.

Table D-1. California Wildlife Habitat Relationships results for all stations where martens were detected.

Sample Unit-Station	Ultramafic Parent Material (Y/N)	WHR Habitat Type	WHR Size Class	WHR Canopy Closure
008-2	N	DFR	6	Dense
018-1	N	MHC	5	Dense
018-2	N	MHC	5	Dense
032-1	N	MRI	4	Dense
044-1	Y	KMC	2	Sparse
045-1	N	MHC	2	Dense
056-1	N	MRI	3	Dense
058-2	Y	MCP	3	Dense
059-1	Y	KMC	3	Moderate
074-2	Y	KMC	3	Open
077-1	N	DFR	5	Dense
077-2	N	MHC	4	Dense
078-1	N	MHC	4	Dense
078-2	N	MHC	4	Dense
084-1	N	MHC	5	Dense
088-2	Y	MCP	3	Dense
096-1	N	MHC	6	Dense
098-1	N	MHC	4	Dense
108-1	N	DFR	5	Dense
109-1	N	DFR	3	Dense
109-2	N	MHC	3	Moderate
118-2	Y	MHW	3	Dense
119-1	Y	MHW	3	Dense
122-1	N	MHC	6	Dense
122-2	N	DFR	5	Dense
132-1	Y	MHC	4	Dense
132-2	Y	MHC	3	Dense
134-1	N	MHC	5	Dense
150-1	N	DFR	6	Dense
152-1	N	DFR	4	Dense
152-2	N	DFR	5	Dense
164-1	Y	DFR	4	Dense
974-1	Y	KMC	3	Open
995-1	N	MHC	6	Dense

APPENDIX E. SAS CODE FOR AIC CALCULATION, ΔAIC, AND CHECK RESIDUALS FOR MODEL FIT. Adapted from SAS code written by J. Dunham and R. Reiman, Department of Fisheries and Wildlife, Oregon State University.

```
OPTIONS LS=85 PS=60;

*Read in data set;

DATA Multi;
  INFILE 'K:\wild\carny\Slauson\Multi.csv' delimiter=',';
  INPUT SYSNO MAAM_det SHRUB_C SERAL_ST $ TREE_COV CONIF MASP MSP $
OG_COMP OLM_COMP OG_PCH OLM_PCH STREAM LOGGED SERP ;
  RUN;

*Transform Aspect Data;

DATA Multi;
    SET Multi;
    RETAIN pi 3.14159;
    aspect=MASP;
    radasp=((aspect+45)/360)*2*pi;
    cosasp=cos(radasp);
  RUN;

*Print and review data for accuracy;

PROC PRINT DATA=Multi;
RUN;

*Model Statement and AIC Calculation;

%MACRO AIC (MODEL, CLASSVARS, XVARS);
TITLE "&MODEL, &CLASSVARS, &XVARS";

*SPECIFY GENERAL STRUCTURE OF LOGISTIC REGRESSION MODEL OUTPUTING
RELEVANT METRICS-MACRO REPLACES & WITH SPECIFIED VARIABLES WHEN
CALLING MACRO ;

PROC GENMOD DATA=Multi DESCENDING;
   CLASS MSP SERAL_ST;
   MODEL MAAM_det= &CLASSVARS &XVARS / DIST=BINOMIAL LINK=LOGIT LRCI;
   ODS OUTPUT MODELFIT=FITSTAT PARAMETERESTIMATES=PARMS
MODELINFO=NUMOBS;
   OUTPUT OUT=OBSTAT PRED=PREDICT ;
   RUN;

*SPECIFY LENGTH AND TYPE OF VARIABLES FROM ODS OUTPUT;

DATA PARMS2 (DROP=df ChiSq ProbChiSq LowerCL UpperCL);
LENGTH MODEL $8  XVARS $20 PARAMETER  $20;

*NOTE-- KEEP PARAMETER NAMES TO <= 20 CHARACTERS;
```

```
MODEL="&MODEL";
XVARS="&XVARS";
SET PARMS;
IF ESTIMATE=0 AND STDERR=0 THEN DELETE;
DROP LEVEL1;
RUN;


DATA NUMOBS2;
LENGTH MODEL $8  XVARS $20;
MODEL="&MODEL";
SET NUMOBS;

*"GRABS" NOBS INFO FROM ODS OUTPUT (PROC PRINT ODS OUTPUT TO SEE
THIS);

      IF LABEL1= 'Observations Used' then nobs=cVALUE1;
IF NOBS NE . ;
KEEP MODEL nobs;
RUN;


DATA FITSTAT2 (DROP=VALUEDF);
LENGTH MODEL $8 XVARS $20 PARAMETER  $20;
MODEL="&MODEL";
XVARS="&XVARS";
SET FITSTAT;
RUN;

DATA TEMP;
MERGE NUMOBS2 FITSTAT2;
BY MODEL;
RUN;

*COMPUTE AICC FOR EACH MODEL;

DATA MODELSUM;
SET TEMP;
IF CRITERION = 'Pearson Chi-Square' then k=NOBS-DF;
RETAIN K;
IF CRITERION='Log Likelihood' then AICC=-2*VALUE +2*K +
(2*K*(K+1))/(NOBS-K-1);
IF CRITERION='Log Likelihood';
DROP VALUE DF CRITERION XVARS;
RUN;

*FOR EACH ITERATION (i.e. MODEL SPECIFIED IN CALL STATEMENT) ADD
RESULTS OF ABOVE TO A FILE (BASE=AICC)
THAT KEEPS TRACK OF ALL ITERATIONS);

PROC APPEND DATA=MODELSUM BASE=AICC FORCE;
RUN;
PROC APPEND DATA=PARMS2 BASE=PARAMEST FORCE;
RUN;
```

```
*TO SEE WHAT THE ABOVE STEPS COMPLETED DO A PROC PRINT STATEMENT FOR
THE ABOVE BASE FILES;

*ENDS MACRO;
%MEND;

*Clear any previous output;

PROC DATASETS LIBRARY=work MEMTYPE=ALL;
  DELETE AIC RP1-RP50; RUN;

*CALL MACRO; SELECT EACH SCALE SET PLUS NULL MODEL AND RUN SEPARATELY

%AIC (NULL, , );

%AIC (ST1_LTM, SERAL_ST cosasp*MSP, CONIF SHRUB_C );
%AIC (ST2_RLIT1, SERAL_ST cosasp*MSP, CONIF );
%AIC (ST3_RLIT2, cosasp*MSP, CONIF SHRUB_C );
%AIC (ST4_HSI, SERAL_ST , TREE_COV CONIF );
%AIC (ST5_COAST_S, SERAL_ST , SHRUB_C );
%AIC (ST6_2COAST_SC, SERAL_ST , CONIF SHRUB_C );
%AIC (ST7_3COAST_SCT, SERAL_ST cosasp*MSP, SHRUB_C );
%AIC (ST8_PAR_SHRUB, , SHRUB_C );
%AIC (ST9_2PAR_SERAL, SERAL_ST , );
%AIC (ST10_PURE_S, SERAL_ST , TREE_COV SHRUB_C );
%AIC (ST11_MESIC_CONIF, cosasp*MSP, CONIF );
%AIC (ST12_2MESIC_SHRUB, cosasp*MSP, SHRUB_C );
%AIC (ST13_3MESIC_SERAL, SERAL_ST cosasp*MSP, );
%AIC (ST14_TOTAL_COVER, , TREE_COV SHRUB_C );
%AIC (ST15_CLOSED_CONIF, , TREE_COV CONIF );

%AIC (LS1_PAR_SERALCOMP1, , OG_COMP );
%AIC (LS2_PAR_SERALCOMP2, , OLM_COMP );
%AIC (LS3_SERALC1_STREAM, , OG_COMP STREAM );
%AIC (LS4_SERALC2_STREAM, , OLM_COMP STREAM );
%AIC (LS5_SERALC1_SERPENTINE, , OG_COMP SERP );
%AIC (LS6_SERALC2_SERPENTINE, , OLM_COMP SERP );
%AIC (LS7_PAR_PATCH1, , OG_PCH );
%AIC (LS8_PAR_PATCH2, , OLM_PCH );
%AIC (LS9_LOGGING, , LOGGED );
%AIC (LS10_SERALC1_LOGGING, , OG_COMP LOGGED );
%AIC (LS11_SERALC2_LOGGING, , OLM_COMP LOGGED );
%AIC (LS12_PATCH1_LOGGING, , OG_PCH LOGGED );
%AIC (LS13_PATCH2_LOGGING, , OLM_PCH LOGGED );
%AIC (LS14_SERALC1_LOG_SERP, , OG_COMP LOGGED SERP );
%AIC (LS15_SERALC2_LOG_SERP, , OLM_COMP LOGGED SERP );
%AIC (LS16_SERALC1_LOG_STREAM, , OG_COMP LOGGED STREAM );
%AIC (LS17_SERALC2_LOG_STREAM, , OLM_COMP LOGGED STREAM );
%AIC (LS18_PATCH1_LOG_STREAM, , OG_PCH LOGGED STREAM );
%AIC (LS19_PATCH2_LOG_STREAM, , OLM_PCH LOGGED STREAM );
%AIC (LS20_PATCH1_LOG_SERP, , OG_PCH LOGGED SERP );
%AIC (LS21_PATCH2_LOG_SERP, , OLM_PCH LOGGED SERP );
```

```
%AIC (LS22_PATCH1_LOG_SERP_STREAM, , OG_PCH LOGGED SERP STREAM );
%AIC (LS23_PATCH2_LOG_SERP_STREAM, , OLM_PCH LOGGED SERP STREAM );
%AIC (LS24_PATCH1_SERPENTINE, , OG_PCH SERP );
%AIC (LS25_PATCH2_SERPENTINE, , OLM_PCH SERP );

%AIC (MS1_SHRUB_SERALC1, , OG_COMP SHRUB_C );
%AIC (MS2_SHRUB_SERALC2, , OLM_COMP SHRUB_C );
%AIC (MS3_SHRUB_PATCH1, , OG_PCH SHRUB_C );
%AIC (MS4_SHRUB_PATCH2, , OLM_PCH SHRUB_C );
%AIC (MS5_SHRUB_TREECOV_SERALC1, , OG_COMP TREE_COV SHRUB_C );
%AIC (MS6_SHRUB_TREECOV_SERALC2, , OLM_COMP TREE_COV SHRUB_C );
%AIC (MS7_SHRUB_TREECOV_PATCH1, , OG_PCH TREE_COV SHRUB_C );
%AIC (MS8_SHRUB_TREECOV_PATCH2, , OLM_PCH TREE_COV SHRUB_C );
%AIC (MS9_SHRUB_LOGGED, , SHRUB_C LOGGED );
%AIC (MS10_SERAL_LOGGED, SERAL_ST, LOGGED );
%AIC (MS11_SERAL_SHRUB_LOGGED, SERAL_ST, SHRUB_C LOGGED );
%AIC (MS12_SHRUB_SERALC1_LOG, , OG_COMP SHRUB_C LOGGED );
%AIC (MS13_SHRUB_SERALC2_LOG, , OLM_COMP SHRUB_C LOGGED );
%AIC (MS14_SHRUB_PATCH1_LOG, , OG_PCH SHRUB_C LOGGED );
%AIC (MS15_SHRUB_PATCH2_LOG, , OLM_PCH SHRUB_C LOGGED );

*THE BELOW STEPS TAKE SUMMARY INFO ON EACH MODEL TO GET AICC
DIFFERENCES AND AKAIKE'S WEIGHTS;

PROC SORT DATA=AICC;
BY MODEL;
RUN;
PROC SORT DATA=PARAMEST;
BY MODEL;
RUN;

DATA ALLTEST;
MERGE AICC PARAMEST ;
BY MODEL;
IF PARAMETER= "Scale" THEN DELETE ;

*A CLUNKY WAY TO GET THE MERGE STATEMENT TO ADD A VARIABLE TO EACH
RECORD IS TO SET A DUMMY VARIABLE THAT YOU LATER "MERGE BY";

DUMMY=1;
drop  NOBS ;
RUN;

*FIND MIN AICC FROM SET OF MODELS AND OUTPUT IT FOR LATER MERGE;

PROC MEANS DATA=ALLTEST MIN NOPRINT;
VAR AICC;
OUTPUT OUT=MINAKAIKE  MIN=MINAICC;
RUN;

*GET PRELIMIMARY DATA FOR WEIGHTS WITH 1 RECORD PER MODEL;

DATA MODELSUM;
SET ALLTEST;
```

```
BY MODEL;
*KEEPS ONLY THE FIRST RECORD OF EACH MODEL-- RECORDS PREVIOUSLY
EXISTED FOR ALL PARAMETERS IN EACH MODEL;

IF FIRST.MODEL;
RUN;

DATA MINAKAIKE;
SET MINAKAIKE;

*AGAIN, CLUNKY WAY OF SETTING UP MERGE;
DUMMY=1;
RUN;

*INCLUDE MINAICC VALUE TO EACH RECORD OF SUMMARY OF AICC VALUES FOR
EACH MODEL;

DATA MODELSUM2;
MERGE  MINAKAIKE MODELSUM;
BY DUMMY;

*COMPUTE AICC DIFFERENCES;

AICCDIF=AICC-MINAICC;

*GET NUMERATOR OF EQUATION TO COMPUTE MODEL WEIGHTS (B&A PAGE 124);

expdif= exp(-.5 * AICCDIF);
DROP _TYPE_ _FREQ_ ;
RUN;

*GET DENOMINATOR OF EQUATION;

PROC MEANS DATA=MODELSUM2 SUM NOPRINT;
VAR EXPDIF;
OUTPUT OUT=SUMEXPON  SUM=SUMEXPD;
RUN;
DATA SUMEXPON;
SET SUMEXPON;
DUMMY=1;
RUN;

*COMPUTE AKAIKE'S WEIGHTS;

DATA MODELSUM3;
MERGE MODELSUM2 SUMEXPON;
BY DUMMY;
w=expdif/sumexpd;
run;

DATA MODELSUM4;
MERGE MODELSUM3 ALLTEST;
BY MODEL;
DROP _TYPE_ _FREQ_ EXPDIF SUMEXPD;
```

```
RUN;

PROC PRINT DATA=MODELSUM4;
RUN;

*PRINT MODEL SUMMARY;

DATA MODELSUM_FINAL;
SET MODELSUM4;
BY MODEL;
IF FIRST.MODEL;
PROC PRINT ;
VAR MODEL K AICC AICCDIF W;
RUN;

*TO GET AICC AND MODEL WEIGHTS FOR EACH MODEL AND THE PAR EST (SE)FOR
EACH PARAM FROM EACH MODEL;

PROC PRINT DATA=MODELSUM4;
RUN;

*Residual check for all models;

%MACRO RESCHECK (MODEL, CLASSVARS, XVARS);
TITLE "Model, &CLASSVARS, &XVARS";
TITLE2 "Multi";

PROC GENMOD DATA=Multi DESCENDING;
  *CLASS &CLASSVARS;
  CLASS MSP SERAL_ST;
  MODEL MAAM_det= &CLASSVARS &XVARS / DIST=BINOMIAL LINK=LOGIT LRCI
obstats residuals;
  *OUTPUT OUT=predout;
  ods output obstats=obstats2 residuals=RESID;
  RUN;
PROC PRINT DATA=OBSTATS2;
RUN;
proc plot data=obstats2 vpercent=50;
plot RESID*(PRED &XVAR)/VREF=0;
RUN;
%MEND;


GOPTIONS NODISPLAY COLORS=(BLACK) GOUTMODE=APPEND;

PROC GPLOT DATA=predout GOUT=RP;
  PLOT RESID*(PRED &XVARS);
 RUN;
QUIT;

GOPTIONS DISPLAY;
PROC GREPLAY IGOUT=RP NOFS
  TEMPLATE=twoxtwo TC=template;
  TDEF twoxtwo
```

```
  1/ ULX=0 ULY=100 URX=50 URY=100
     LLX=0 LLY=50 LRX=50 LRY=50
  2/ COPY=1 XLATEX=50
  3/ COPY=1 XLATEY=-50
  4/ COPY=3 XLATEX=50;
  TREPLAY 1:1 2:2 3:3 4:4;
 RUN;
QUIT;
%MEND;
*Submit this for all models in the set;
*%RESCHECK (POS.SERAL.SHRUB, SERAL_STAND , SHRUB_COV );

%RESCHECK (NULL, , );

%RESCHECK (ST1_LTM, SERAL_ST cosasp*MSP, CONIF SHRUB_C );
%RESCHECK (ST2_RLIT1, SERAL_ST cosasp*MSP, CONIF );
%RESCHECK (ST3_RLIT2, cosasp*MSP, CONIF SHRUB_C );
%RESCHECK (ST4_HSI, SERAL_ST , TREE_COV CONIF );
%RESCHECK (ST5_COAST_S, SERAL_ST , SHRUB_C );
%RESCHECK (ST6_2COAST_SC, SERAL_ST , CONIF SHRUB_C );
%RESCHECK (ST7_3COAST_SCT, SERAL_ST cosasp*MSP, SHRUB_C );
%RESCHECK (ST8_PAR_SHRUB, , SHRUB_C );
%RESCHECK (ST9_2PAR_SERAL, SERAL_ST , );
%RESCHECK (ST10_PURE_S, SERAL_ST , TREE_COV SHRUB_C );
%RESCHECK (ST11_MESIC_CONIF, cosasp*MSP, CONIF );
%RESCHECK (ST12_2MESIC_SHRUB, cosasp*MSP, SHRUB_C );
%RESCHECK (ST13_3MESIC_SERAL, SERAL_ST cosasp*MSP, );
%RESCHECK (ST14_TOTAL_COVER, , TREE_COV SHRUB_C );
%RESCHECK (ST15_CLOSED_CONIF, , TREE_COV CONIF );

%RESCHECK (LS1_PAR_SERALCOMP1, , OG_COMP );
%RESCHECK (LS2_PAR_SERALCOMP2, , OLM_COMP );
%RESCHECK (LS3_SERALC1_STREAM, , OG_COMP STREAM );
%RESCHECK (LS4_SERALC2_STREAM, , OLM_COMP STREAM );
%RESCHECK (LS5_SERALC1_SERPENTINE, , OG_COMP SERP );
%RESCHECK (LS6_SERALC2_SERPENTINE, , OLM_COMP SERP );
%RESCHECK (LS7_PAR_PATCH1, , OG_PCH );
%RESCHECK (LS8_PAR_PATCH2, , OLM_PCH );
%RESCHECK (LS9_LOGGING, , LOGGED );
%RESCHECK (LS10_SERALC1_LOGGING, , OG_COMP LOGGED );
%RESCHECK (LS11_SERALC2_LOGGING, , OLM_COMP LOGGED );
%RESCHECK (LS12_PATCH1_LOGGING, , OG_PCH LOGGED );
%RESCHECK (LS13_PATCH2_LOGGING, , OLM_PCH LOGGED );
%RESCHECK (LS14_SERALC1_LOG_SERP, , OG_COMP LOGGED SERP );
%RESCHECK (LS15_SERALC2_LOG_SERP, , OLM_COMP LOGGED SERP );
%RESCHECK (LS16_SERALC1_LOG_STREAM, , OG_COMP LOGGED STREAM );
%RESCHECK (LS17_SERALC2_LOG_STREAM, , OLM_COMP LOGGED STREAM );
%RESCHECK (LS18_PATCH1_LOG_STREAM, , OG_PCH LOGGED STREAM );
%RESCHECK (LS19_PATCH2_LOG_STREAM, , OLM_PCH LOGGED STREAM );
%RESCHECK (LS20_PATCH1_LOG_SERP, , OG_PCH LOGGED SERP );
%RESCHECK (LS21_PATCH2_LOG_SERP, , OLM_PCH LOGGED SERP );
%RESCHECK (LS22_PATCH1_LOG_SERP_STREAM, , OG_PCH LOGGED SERP STREAM
);
```

```
%RESCHECK (LS23_PATCH2_LOG_SERP_STREAM, , OLM_PCH LOGGED SERP STREAM
);
%RESCHECK (LS24_PATCH1_SERPENTINE, , OG_PCH SERP );
%RESCHECK (LS25_PATCH2_SERPENTINE, , OLM_PCH SERP );

%RESCHECK (MS1_SHRUB_SERALC1, , OG_COMP SHRUB_C );
%RESCHECK (MS2_SHRUB_SERALC2, , OLM_COMP SHRUB_C );
%RESCHECK (MS3_SHRUB_PATCH1, , OG_PCH SHRUB_C );
%RESCHECK (MS4_SHRUB_PATCH2, , OLM_PCH SHRUB_C );
%RESCHECK (MS5_SHRUB_TREECOV_SERALC1, , OG_COMP TREE_COV SHRUB_C );
%RESCHECK (MS6_SHRUB_TREECOV_SERALC2, , OLM_COMP TREE_COV SHRUB_C );
%RESCHECK (MS7_SHRUB_TREECOV_PATCH1, , OG_PCH TREE_COV SHRUB_C );
%RESCHECK (MS8_SHRUB_TREECOV_PATCH2, , OLM_PCH TREE_COV SHRUB_C );
%RESCHECK (MS9_SHRUB_LOGGED, , SHRUB_C LOGGED );
%RESCHECK (MS10_SERAL_LOGGED, SERAL_ST, LOGGED );
%RESCHECK (MS11_SERAL_SHRUB_LOGGED, SERAL_ST, SHRUB_C LOGGED );
%RESCHECK (MS12_SHRUB_SERALC1_LOG, , OG_COMP SHRUB_C LOGGED );
%RESCHECK (MS13_SHRUB_SERALC2_LOG, , OLM_COMP SHRUB_C LOGGED );
%RESCHECK (MS14_SHRUB_PATCH1_LOG, , OG_PCH SHRUB_C LOGGED );
%RESCHECK(MS15_SHRUB_PATCH2_LOG, , OLM_PCH SHRUB_C LOGGED );
```

APPENDIX F. UNIVARIATE DESCRIPTIVE STATISTICS FOR EACH CONTINUOUS STAND AND HOME RANGE SCALE VARIABLE.

Table F-1. Univariate descriptive statistics for stand scale variables.

Variable	Mean (SD)	
	Detection (n=26)	Non-detection (n=133)
% Shrub Cover	74.4% (21.3)	47.4% (26.8)
Non-serpentine	73.5% (22.3)	43.8% (25.5)
Serpentine	76.1% (20.3)	75.6% (19.5)
Tree Canopy Closure	72.6% (27.6)	72.0% (23.4)
Non-serpentine	85.8% (9.0)	74.4% (22.0)
Serpentine	47.7% (33.9)	53.3% (26.0)
% Relative Conifer	82.0% (17.2)	70.2% (29.1)
Non-serpentine	74.7% (16.4)	67.1% (29.2)
Serpentine	96.0% (7.4)	94.3% (11.9)

*Sample sizes for detections and non-detections at non-serpentine (n = 15, n = 118) and serpentine (n = 9, n = 17) stands.

Table F-2. Univariate descriptive statistics for home-range scale variables.

Variable	Mean (SD) Detection (n=26)	Mean (SD) Non-detection (n=133)
Old Growth Composition	75.2 Ha (54.5)	55.5 Ha (51.3)
Non-serpentine	91.2 Ha (48.6)	56.0 Ha (51.3)
Serpentine	45.0 Ha (54.8)	50.9 Ha (53.2)
OG and LM Composition	139.0 Ha (58.1)	113.3 Ha (71.3)
Non-serpentine	166.6 Ha (42.5)	115.2 Ha (74.1)
Serpentine	86.7 Ha (47.4)	97.8 Ha (41.2)
Largest OG Patch	64.3 Ha (49.8)	41.2 Ha (43.5)
Non-serpentine	78.1 Ha (43.2)	42.4 Ha (45.5)
Serpentine	38.3 Ha (53.4)	31.3 Ha (20.5)
Largest OG and LM Patch	113.5 Ha (64.8)	86.3 Ha (67.5)
Non-serpentine	141.6 Ha (51.1)	88.2 Ha (70.1)
Serpentine	60.5 Ha (55.4)	70.9 Ha (40.2)
Amount of Serpentine	95.9 Ha (124.7)	31.4 Ha (64.8)
Non-serpentine	9.6 Ha (22.9)	13.1 Ha (31.3)
Serpentine	258.8 Ha (43.3)	174.9 Ha (81.1)
Amount of Riparian	2293 m (1355)	2186 m (1438)
Non-serpentine	2570 m (1410)	2125 m (1462)
Serpentine	1770 m (1135)	2669 m (1155)
Amount Logged	15.6 % (15.8)	30.7 % (36.3)
Non-serpentine	18.2 % (18.3)	33.4 % (37.5)
Serpentine	10.6 % (8.2)	9.2 % (12.4)

APPENDIX G. SUMMARY OF POTENTIAL NATURAL VEGETATION (PNV) SERIES AND SUBSERIES FOR STANDS SAMPLED.

PNV Type (Code) Subseries (Code)	Total # Sampled	Marten Detections
Tanoak Series (00)	**76**	**16**
LIDE2-CHLA (0001)	3	1
LIDE2-QUCH2 (0017)	14	2
LIDE2-CACH2 (0019)	21	4
LIDE2-ACER (0023)	2	1
LIDE2-VAOV (0038)	22	5
LIDE2-GASH (0039)	12	2
LIDE2-DRY SHRUB (0041)	2	1
Port-Orford Cedar Series (01)	**1**	**0**
CHLA-ABC0 (0102)	1	
White Fir Series (02)	**20**	**0**
ABCO-ABCO (0202)	1	
ABCO-ABMAS (0203)	2	
ABCO-PSME (0205)	14	
ABCO-LIDE3 (0216)	1	
ABCO-PIBR (0218)	1	
ABCO-CACH2 (0219)	1	
Red Fir Series (03)	**2**	**0**
ABMAS-PIMO3 (0315)	1	
ABMAS-PIBR (0318)	1	

PNV Type (Code) Subseries (Code)	Total # Sampled	Marten Detections
Jeffrey Pine Series (04)	**5**	**0**
PIJE-PSME (0405)	1	
PIJE-LIDE3 (0416)	4	
Douglas-fir Series (05)	**35**	**5**
PSME-QUCH2 (0517)	5	0
PSME-CACH2 (0519)	19	4
PSME/QUVA (0542)	11	1
Sugar Pine Series (09)	**1**	**0**
PILA-PIMO3 (0915)	1	
Redwood Series (14)	**13**	**0**
Unknown (1400)	8	
SESE2-XXX (1401)	3	
SESE2-PSME (1405)	2	
Western White Pine (15)	**9**	**5**
PIMO3-PSME (1505)	3	1
PIMO3-PICO1 (1506)	6	4
Riparian (28)	**1**	**0**
UNKNOWN (2899)	1	

Species Codes:
ABCO: white fir, ABMAS: red fir, ACER: maple sp., CACH2: chinquapin, CHLA: Port-Orford Cedar, GASH: salal, LIDE2: tanoak, LIDE3: Incense cedar, PIBR: Brewer's spruce, PICO1: lodgepole pine, PIJE: Jeffrey pine, PILA: sugar pine, PIMO3: Western white pine, PSME: Douglas-fir, QUCH2: canyon live oak, QUVA: huckleberry oak, SESE2: redwood, VAOV

Figure G-1. Percent used and available for the five most frequently sampled vegetation series.

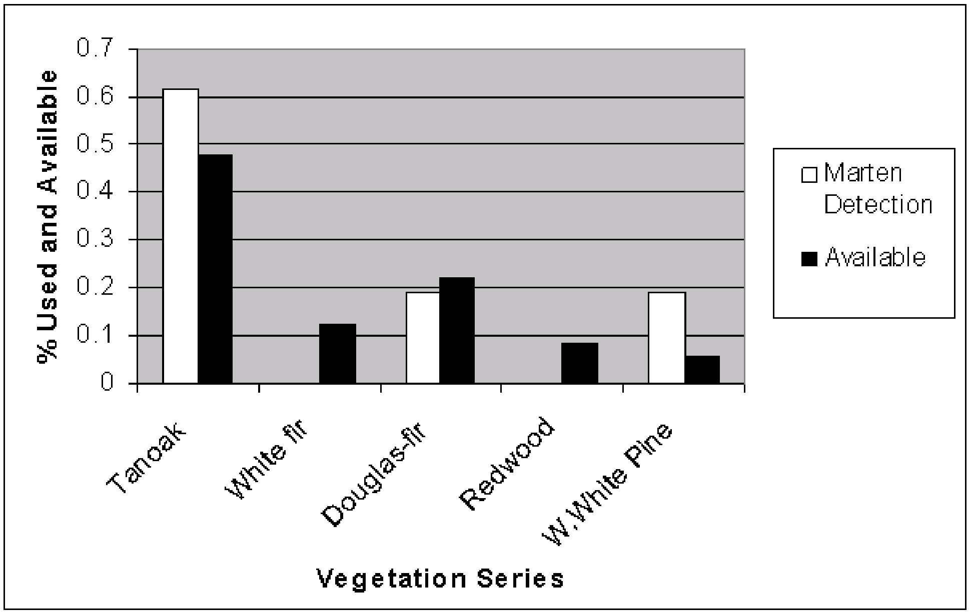

Figure G-2. Seral stage distribution by vegetation series for all 159 sampled stands.